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6/30/2000

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
1200 Sixth Avenue
Seattle, WA 98101

JUN 30 2000

Reply To
Attn Of: ECL-117

MEMORANDUM

SUBJECT: EPA's Concurrence on the Five Year Review Report for the Naval Undersea Warfare Center, Keyport, Washington

FROM: Mike Gearheard
Director, Environmental Cleanup Office

EPA Region 10 has reviewed the Five Year Review report for the Naval Undersea Warfare Center, Keyport, Washington, dated June 2000. EPA has reviewed the report for technical adequacy, accuracy, and consistency with EPA guidance. EPA's conclusions are based primarily on the information presented in this report. The Washington Department of Ecology is the lead regulatory agency overseeing this cleanup.

EPA concurs with the report findings, with one exception. EPA believes an Explanation of Significant Differences (ESD) is needed to enhance the OU 2 ROD's institutional control requirements to ensure long-term protectiveness for those areas that have not been cleaned up to levels that allow unlimited use and unlimited exposure. The need for, and the requirements for, such an ESD is stated in Region 10 Final Policy on the Use of Institutional Controls at Federal Facilities, May 3, 1999. EPA believes that such an ESD should be completed no later than December 31, 2000.

cc: Bruce Cochran, Washington Department of Ecology
Sandy Kienholz, EFA NW

DEPARTMENT OF THE NAVY
ENGINEERING FIELD ACTIVITY, NORTHWEST
NAVAL FACILITIES ENGINEERING COMMAND
19917 7TH AVENUE N.E.
POULSBO, WASHINGTON 98370-7570

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Ser 05ER1SK/8818
June 23, 2000

Mr. Bruce Cochran
Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, WA 98504-7600

Ms. Nancy Harney
US Environmental Protection Agency
1200 6th Avenue
Seattle, Wa 98101

NAVAL UNDERSEA WARFARE CENTER, DIVISION KEYPORT, FINAL FIVE-YEAR REVIEW, OU1 AND OU2, NAVAL UNDERSEA WARFARE CENTER, DIVISION KEYPORT

Please find enclosed two copies of the Final Five-Year Review for OU1 and OU2 at NUWC Keyport. Thank you for your comments leading to the finalization of this document.

If I can be of any further assistance, please contact me at (360) 396-0012.

Sincerely,

Sandy Kienholz

SANDY KIENHOLZ
Remedial Project Manager

cc:
Carl Haselman, NUWC Division Keyport (Code 8032) w/1 enclosure
Mick Butterfield, Subase Bangor (Code B451 Public Works) w/4 enclosures
Scott Pozarycki, Suquamish Tribe w/1 enclosure

Final

Five-Year Review
Operable Unit 1 and Operable Unit 2
Naval Undersea Warfare Center
Division
Keyport, Washington

Contract Task Order 002

Prepared for

United States Navy
Engineering Field Activity, Northwest

Prepared by

CH2M HILL Constructors, Inc.
TEC LTM Team

June 2000

Contract No. 44255-98-D-4416

ENVIRONMENTAL SERVICES MONITORING

LONG-TERM MONITORING

FIVE-YEAR REVIEW

FINAL

Operable Unit 1 and Operable Unit 2
Naval Undersea Warfare Center
Division Keyport
Keyport, Washington
CTO 0002

THE TEC LTM TEAM
The Environmental Company, Inc.
CH2MHILL
Pentec ENVIRONMENTAL

June 2000

Contents

List of Figures

List of Tables

Figures and tables are located at the end of the main text.

Acronyms and Abbreviations

ARAR	appropriate, relevant, and applicable requirement
bgs	below ground surface
CAH	chlorinated aliphatic hydrocarbon
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
DNAPL	dense nonaqeous-phase liquid
EPA	U.S. Environmental Protection Agency
ESD	explanation of significant difference
FFA	Federal Facility Agreement
IAS	Initial Assessment Study
LTM	long-term monitoring
MCL	maximum contaminant level
MOA	Memorandum of Agreement
msl	mean sea level
MTCA	Model Toxics Control Act
Navy	U.S. Department of the Navy
NPL	National Priorities List
NUWC	Naval Undersea Warfare Center
OU	Operable Unit
PCB	polychlorinated biphenyl
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SMS	Sediment Management Standard
TCE	trichloroethene
TPH	total petroleum hydrocarbon
UST	underground storage tank
VOC	volatile organic compound

1. Introduction

1.1 Purpose

The purpose of this statutory Five-Year Review is to ensure that the remedial actions selected in the Records of Decision (RODs) for Operable Units (OUs) 1 and 2 at Naval Undersea Warfare Center (NUWC) Keyport remain protective of public health and the environment and are functioning as designed. The issuance of the ROD for OU2 on September 1994 and the start date of the Remedial Action Work Plan preparation in July 1995 triggered this periodic (five-year) review requirement. The scope of this review covers selected remedies at the two OUs where hazardous materials either have been left in place or have been remediated/removed during the review period (1995-2000), and where restrictions remain on use and/or monitoring programs remain implemented.

This Five-Year Review also includes a time-critical removal action conducted at Site 23 as part of the Building 21 demolition. Although Site 23 was not included as one of the original sites to be investigated and was not included in the OU2 ROD, this time-critical removal action was performed under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The results of the Site 23 removal action are described in Section 3.3.

1.2 Authority Statement

The U.S. Department of the Navy (Navy) has conducted this review pursuant to CERCLA, 42 USC 9621(c); the National Contingency Plan (NCP), 40 CFR 300.430(f)(4)(ii); Executive Order 12580 (January 23, 1987); and Section 19.1 of the Federal Facility Agreement (FFA) for NUWC Keyport dated July 1990. This document is consistent with the Draft Comprehensive Five-Year Review Guidance published by U.S. Environmental Protection Agency (EPA) OSWER Directive 9355.7-03B-P (U.S. EPA, 1999). The Navy is the lead agency for remediation of NUWC Keyport OU1 and OU2, and has performed extensive remedial action under the Defense Environmental Restoration Program.

Under a Memorandum of Agreement (MOA) between EPA and the Washington State Department of Ecology (Ecology), Ecology is responsible for ensuring that applicable federal and state environmental regulations have been addressed, and that the corrective actions taken at specific areas are consistent with appropriate environmental standards that are protective of human health and the environment. Consistent with the MOA and the FFA, project managers for EPA and Ecology have participated in this review. This review is limited to only those areas being remediated under CERCLA authority where hazardous waste has been removed or left in place.

1.3 Installation Description

NUWC Division, Keyport occupies 340 acres (including tidelands) adjacent to the town of Keyport in Kitsap County, Washington, on a small peninsula in the central portion of Puget Sound. The Keyport property was acquired by the Navy in 1913 with property acquisition continuing through World War II. The property was first used as a quiet-water range for torpedo testing. The first range facility was located in Port Orchard Inlet southeast of the site.

During the early 1960s, Keyport's role was expanded to include manufacturing and fabrication, such as welding, metal plating, carpentry, and sheet metal work. Further expansion in 1966 consisted of a new torpedo shop, and in 1978 the functions broadened to include various undersea warfare weapons and systems engineering and development activities. In 1992, the name of the facility was changed to NUWC Keyport. Operations currently include engineering, fabrication, assembly, and testing of underwater weapons systems.

In September 1984, the Navy conducted an Initial Assessment Study (IAS), performed under the Navy Assessment and Control of Installation Pollutants program, to identify areas of possible environmental contamination resulting from past methods of storage, handling, and disposal of hazardous substances at NUWC Keyport (SCS Engineers, 1984). Six specific areas (Areas 1, 2, 3, 5, 8, and 9) were recommended for further investigation in the remedial investigation/feasibility study (RI/FS). Under the Environmental Restoration Program, the RI/FS process for these six areas began in 1988, and the final RI/FS reports were submitted in October and November of 1993 (URS and SAIC, 1993).

In October 1989, NUWC Keyport was officially listed on the National Priorities List (NPL). In response to the NPL designation, the Navy, EPA, and Ecology entered into an interagency FFA in July 1990 for the investigation, remediation, and restoration of the site. After the Final ROD for OU2 was approved in September 1994, remedial actions were implemented at the five areas within OU2 from 1995 through 2000. After initial remedial actions were conducted and completed, no further actions were issued at Areas 3, 5, and 9. The OU1 Final ROD was approved in September 1998, and remedial actions have been conducted continuously at the site until the present time.

1.4 Physical Settings

NUWC Keyport is bordered by Liberty Bay on the east and north and Port Orchard Inlet on the southeast (Figure 1-1). The topography of the site rises gently from the shoreline to an average of 25 to 30 feet above mean sea level (msl) and then rises steeply to approximately 130 feet above msl at the southeast corner of the site.

Marine or brackish water bodies on and near the site consist of Liberty Bay, Dogfish Bay, the tide flats, a marsh, and the shallow lagoon. Freshwater bodies include two creeks draining into the marsh pond, and two creeks that discharge into the lagoon.

The terrestrial sediment in the Keyport area generally includes coarse-grained glacial deposits and finer-grained nonglacial deposits. Most of NUWC Keyport is underlain by a thick nonglacial silt and clay informally known as the Clover Park Unit. This unit is commonly about 100 feet thick, and is an aquitard separating the unconfined aquifer above (referred to as the "upper aquifer") and the intermediate aquifer beneath it.

2. Operable Unit Descriptions and Remedial Action Objectives

CERCLA activities at NUWC Keyport originally involved one operable unit, which included the landfill and all other areas of concern. Because of public concerns about the landfill, it was determined that the site should be divided into two OUs for efficient administrative handling of the remediation of the site (Figure 2-1). OU1 consists of Area 1 (the former base landfill); OU2 consists of the remaining areas of concerns (Areas 2, 3, 5, 8, and 9). Two separate RODs were prepared for NUWC Keyport: the Final ROD for OU2 was approved in September 1994 (URS, 1994), and the Final ROD for OU1 was approved in September 1998 (URS, 1998). The final ROD for OU2 was modified by one Explanation of Significant Difference (ESD) dated March 15, 1996 (EA, 1996c).

2.1 Operable Unit 1

OU1 consists of Area 1, the former base landfill, which comprises approximately 9 acres in the western part of the base next to a wetland area and the tide flats that flow into Dogfish Bay (Figure 2-2). Most of the landfill area was formerly a marshland. The landfill is unlined at the bottom and the top is covered with areas of grass, trees, and asphalt. The landfill was the primary disposal area for domestic and industrial wastes generated by the base from the 1930s until 1973, when the landfill was closed. A burn pile for trash and demolition debris was located at the north end of the landfill from the 1930s to the 1960s. Unburned or partially burned materials from this pile were buried in the landfill or pushed into the marsh. A trash incinerator was operated at the north end of the landfill from the 1930s to the 1960s; incinerator ash was disposed of in the landfill. Burning continued at the landfill until the early 1970s.

During various site investigation and assessment studies between 1984 and 1988, Area 1 was determined to have possible environmental contamination that might impact the environment. An RI/FS was conducted at Area 1 between 1988 and 1993, after which human health and ecological risk assessments were conducted (URS and SAIC, 1993). Based on the results of these studies, the feasibility study evaluated seven remedial alternatives for Area 1 and the Navy, Ecology, and EPA selected a preferred remedial alternative. This preferred alternative was described in the 1994 proposed plan. Because public comments were not favorable to the preferred remedial alternative, the proposed plan was withdrawn and Area 1 was separated from the other areas to become OU1.

To address the public's concerns, the Navy, Ecology, and EPA conducted further site characterization to collect data to supplement the remedial investigation. Starting in 1995 and ending in September 1996, five quarterly rounds of sampling were conducted. The additional data were used to evaluate the potential risks from the following three key contaminant of concern (COC) pathways at OU1:

- Drinking water pathway
- Seafood ingestion pathway
- Ecological pathway

The environmental media that might have impacted the pathways are groundwater, surface water, and sediment (downgradient of OU1). New data from the site characterizations were discussed and evaluated in the Summary Data Assessment Report (SAIC and URS, 1997), which supplemented the Remedial Investigation Report. The supplemental focused feasibility study evaluated several additional alternatives, from which a new preferred remedial alternative was selected and eventually accepted based on public comments. The final OU1 ROD was approved in September 1998.

Based on the original remedial investigation and the supplemental data assessment, two classes of contaminants were identified as COCs for the three main potential exposure pathways of interest (see above): chlorinated aliphatic hydrocarbons (CAHs, a class of volatile organic compounds [VOCs]) and polychlorinated biphenyls (PCBs). The CAHs were identified as COCs because of the drinking water and seafood ingestion pathways.

CAHs are present in the upper and intermediate aquifers, with concentrations in the upper aquifer greater than those in the intermediate aquifer by one order of magnitude or more. The CAHs have formed plumes in both aquifers, although field data collected so far do not indicate the presence of dense, nonaqueous-phase liquid (DNAPL) bodies in either aquifer. Groundwater from the southern part of the landfill has the highest concentrations of CAHs, and some CAHs have been detected in the adjacent surface water, particularly in the marsh downgradient of the landfill. The presence of these compounds in the marsh water appear to be the direct result of ongoing discharge from the upper aquifer into the marsh. Data also indicated that mobile CAH contaminants in the intermediate aquifer would eventually be discharged to surface water in the tide flats or Dogfish Bay.

Current hydrogeologic conditions direct groundwater from both the upper and intermediate aquifers into the adjacent surface water and away from areas where drinking water wells exist or could exist in the future.

PCBs were detected in the groundwater of the upper aquifer, seep, aquatic sediments, and clam tissue samples. PCBs were not detected in the intermediate aquifer. Because the PCBs measured in the seep are discharging directly into the marsh, it is likely that many of the PCBs currently migrating from the landfill into the marsh are coming from the seep, instead of the groundwater where PCB detection levels are low. Although PCB concentrations in the creek sediments were below levels requiring active cleanup, a decision was reached to remove the sediments to prevent future movement into the tideflats and Dogfish Bay and accumulation in harmful quantities.

Risk assessments indicated that direct exposure to the COCs within the landfill could cause human health risk above acceptable risk levels.

The major components of the selected remedy are as follows:

- Treat CAH hot spots in the landfill by phytoremediation using poplar trees
- Remove PCB-contaminated sediments from around the seep area, which has the highest PCB concentrations

- Upgrade the tide gate
- Upgrade and maintain the landfill cover
- Conduct long-term monitoring (LTM)
- Take contingent actions for off-base domestic wells, if necessary
- Implement institutional controls

The LTM remedy includes three components: phytoremediation monitoring, intrinsic bioremediation monitoring, and risk compliance monitoring. The rationale for these remedies will be discussed in Section 3.1.

2.2 Operable Unit 2

OU2 consists of the following areas:

- Area 2 – Van Meter Road Spill/Drum Storage Area
- Area 3 – Otto Fuel Leak Area (not subject to Five-Year Review)
- Area 5 – Sludge Disposal Area (not subject to Five-Year Review)
- Area 8 – Plating Shop Waste/Oil Spill Area
- Area 9 – Liberty Bay (not subject to Five-Year Review)

The OU2 ROD specified that only Areas 2 and 8 are subject to the Five-Year Review. No further action was selected for Area 3; confirmation sampling was required at Areas 5 and 9 to determine their eligibility for the Five-Year Review. Confirmation sampling was conducted at Area 5 for groundwater and at Area 9 for marine sediment in 1995 (EA, 1996a, b). Results of the confirmation sampling at both areas indicated contamination did not exceed any of the remediation goals set for those areas; therefore, no further action was selected for Areas 5 and 9 in the ROD. The land use continues to be unrestricted at these areas; as such, they are not subject to this Five-Year Review.

2.2.1 Area 2 – Van Meter Road Spill/Drum Storage Area

Area 2 is located on the southwest corner of NUWC Keyport (Figure 2-1). It is bounded to the north and east by Westfall Road, to the west by Keys Road, and to the south by a sharp topographic rise representing the southern limit of NUWC Keyport. Van Meter Road essentially bisects the area in a north-south direction. Area 2 is composed of three distinct sites: Van Meter Road spill area, Building 734 drum storage area located just west of Van Meter Road, and Building 957 drum storage area located immediately east of Van Meter Road (Figure 2-3).

In 1976, approximately 2,000 to 5,000 gallons of plating shop wastes spilled from a tanker truck on the pavement near Van Meter Road and impacted a nearby stream (SCS Engineers, 1984). Additionally, two unpaved areas associated with the two drum storage areas were active from the 1940s through the 1960s. These two areas were reportedly used to store all chemicals (including solvents, fuel/oil) used at NUWC Keyport during this time period. It was estimated that between 4,000 and 8,000 gallons of these chemicals were discharged into the two unpaved areas (SCS Engineers, 1984).

The 1984 IAS identified Area 2 for further investigation in the RI/FS. The RI/FS process for the six areas of OU2 began in 1988, and the final RI/FS reports were submitted in October

and November of 1993. Media sampled during the Area 2 remedial investigation include air, soil, stream sediment, and groundwater. Based on the sampling results, human health and ecological assessments were conducted. The ecological risk assessment did not identify any significant risks to terrestrial or aquatic organisms at Area 2. For the drum storage area, the human health risk assessment did not identify any significant risk to current workers; however, it did indicate possible risks to hypothetical future residents at the drum storage area from exposure to soil and groundwater. These risks are primarily associated with trichloroethene (TCE) and vinyl chloride. No significant risk was identified at the Van Meter Road plating shop waste spill. Based on the risk analyses, other COCs do not present significant additional risk (URS, 1994).

TCE and vinyl chloride were detected in some of the groundwater samples collected from the upper aquifer at levels that exceeded the drinking water standards. Because of the relatively low concentration levels of VOCs in the groundwater, the potential for offsite migration was determined to be low. While levels of the primary COCs exceeded the appropriate, relevant, and applicable requirements (ARARs), a decision was reached in the ROD that active measures to remediate the groundwater were not presently appropriate given the low contaminant concentrations, the high cost to remediate such low concentrations, and the ability to effectively preclude future residential use and groundwater use at this area through appropriate institutional controls.

The selected remedies for Area 2 are groundwater monitoring and institutional controls. Long-term groundwater monitoring is being conducted to document the decline of VOC concentrations through natural attenuation in the affected upper aquifer. The long-term groundwater monitoring will be used to establish trends in groundwater chemical concentrations and to determine when the institutional controls can be discontinued.

Institutional controls to be implemented at Area 2, as prescribed in the ROD (URS, 1994), are: (1) prevent future residential land use; (2) control physical access to the site; (3) prevent construction of wells and use of groundwater except for environmental monitoring and future remedial purposes; and (4) restrict future construction activities at Area 2 and implement preventive measures restricting future intrusive construction activities in the area (e.g., soil excavation).

2.2.2 Area 8 – Plating Shop Waste/Oil Spill Area

Area 8 occupies about 1 acre on the eastern portion of NUWC Keyport and surrounds the location of the former plating shop (Building 72) (Figures 2-1 and 2-4). Building 72 was demolished in 1999 and replaced by an asphalt-paved parking area. The site is located in a heavily industrialized part of the facility bordered by Liberty Bay to the south and east (Figure 2-4). The area is predominantly flat and almost entirely paved or covered by buildings.

Past releases at Area 8 include spillage of chrome plating solution onto the ground; discharge of plating wastes into a utility trench; and leakage of plating solutions through cracks in the plating shop floor, waste disposal pipes, and sumps. VOCs present in the solvents used in the plating shop were released during plating shop operation. Petroleum hydrocarbons (diesel and heavy oil) were released to the environment from leaky underground storage tanks (USTs) and underground concrete vaults located within Area 8.

Area 8 was investigated and characterized along with other areas during the IAS and RI/FS. In addition, limited investigations and removal actions were performed to contain and remove plating solutions and wastes that were released from the 1980s through the early 1990s. Media sampled during the remedial investigation include subsurface soil, groundwater, and seeps and piezometer water at the adjacent beach.

For subsurface soil, arsenic, cadmium, and chromium were identified as COCs, and are considered major contributors to human health risk at the site. The source of inorganic chemicals detected at Area 8 is believed to be the metal plating activities associated with Building 72, except for low concentrations of detected arsenic that were suspected to be related to background concentrations. As a result, arsenic was dropped as one of the COC at the site.

For groundwater, 10 inorganic chemicals (antimony, arsenic, cadmium, chromium [hexavalent], copper, lead, manganese, nickel, thallium, and zinc) exceeded the maximum contaminant levels (Federal and State MCLs) for surface water protection or the Model Toxics Control Act (MTCA) Method B levels (for protection of human health in groundwater). An inorganic chemical plume was found extending from the western portion of Building 72 toward Liberty Bay to the east and southeast (URS, 1994). The inorganic concentrations generally decrease eastward towards Liberty Bay. Within the inorganic plume, the distribution of cadmium and chromium were well defined and could be traced to former operations of Building 72 (e.g., the chromium plume could be traced to the former chrome room in Building 72). Several other metals (copper, nickel, and zinc) detected in this area have similar distribution patterns as well.

For groundwater, 12 VOCs exceeded the Federal and State MCLs (for surface water protection criteria) or MTCA Method B levels (for protection of human health in groundwater). The most frequently detected organic compounds in samples from shallow groundwater monitoring wells and seeps were TCE; 1,1,1-trichloroethane; 1,2-dichloroethenes; and 1,1-dichloroethene. These compounds form a plume in the upper aquifer that extends from the eastern and southern sides of Building 72 eastward and southeastward to the intertidal zone of Liberty Bay (URS, 1994). Based on the remedial investigation results, the areal extent of the VOC plume is larger than the inorganic plume. Three of the four VOCs were also detected at lower concentrations in groundwater samples from an intermediate-depth well (MW8-16) (screened at 45 feet below ground surface [bgs]). No VOCs were found in the deepest well (MW8-15) above the Clover Park unit. As a result, the presence of DNAPL was not conclusive during the remedial investigation. The principal source of these VOCs is believed to be solvents used in Building 72. It is also possible that some of the VOCs originated from historical use of solvents in adjacent buildings.

Petroleum hydrocarbons and aromatic compounds identified as heavy fuel oils were detected in groundwater samples from locations around Buildings 181 and 804. The source of these compounds is believed to be the former fuel storage vaults at these two buildings. The total petroleum hydrocarbon (TPH) contamination was remediated under the UST program rather than CERCLA. The remediation was conducted as an independent action under MTCA regulations (WAC 173-340-450), and it is not included in this Five-Year Review.

Because of Area 8 groundwater discharges into Liberty Bay, there is a potential for chemical migration from the groundwater to the marine environment. During the remedial investigation, some beach seep samples at Area 8 exceeded surface water quality criteria for metals. No exceedances were identified in samples taken from Liberty Bay surface water.

The baseline risk assessment found unacceptable human health risk for the current industrial exposure scenario. The results also indicated that chemicals in soils and groundwater at Area 8 pose unacceptable risk to hypothetical future residents, although site use will remain industrial for the foreseeable future. Exposure pathways driving risk included ingestion of groundwater, inhalation of volatiles during household use of groundwater, and ingestion of homegrown vegetables.

No ecological risk were identified for terrestrial organisms because of lack of significant habitat at Area 8. Based on the remedial investigation data, ecological risk assessment for current conditions indicated that shallow groundwater from Area 8 discharging to Liberty Bay has not caused significant risk to marine organisms. However, as Area 8 groundwater continues to discharge into Liberty Bay, the groundwater contaminants could lead to future risks in the marine environment.

Remedial measures protective of marine biota and human health were evaluated for soil/sediment, groundwater, and surface water. Pathways included ingestion of soil, fish, and shellfish. Based on the remedial investigation and risk assessment results, remediation alternatives were evaluated for Area 8 soil and groundwater, and the ROD specified that the following remediation alternative be implemented at the site:

- Removal of vadose zone soil hot spots for offsite disposal
- Continuous groundwater monitoring
- Sediment and tissue monitoring
- Institutional controls to restrict residential use of the site

An ESD was developed to clarify that the soil remedial action at Area 8 would be based on total chromium content in the soil, conservatively assuming all of the chromium was in the most toxic +6 form (based on previous groundwater sampling results on chromium speciation) (EA, 1996c). The ESD explained that this approach would be taken to minimize the risks of error and to be conservative. The ESD also revised the work schedule to allow for testing and removal of soils after additional sampling to address the change above.

The remedial actions would not meet groundwater remediation goals based on drinking water criteria, nor the goals for the protection of adjacent surface water throughout the site. Virtually all of the fill area would have to be excavated to meet these goals, and the cost of doing this was deemed disproportionate to the benefit. A risk management decision was made that the groundwater compliance criteria would be measured at the nearshore wells as conditional points of compliance. The requirements for using conditional points of compliance were achieved by the hot spot soil removal and monitoring. The groundwater remediation goals are being met by actions taken at this site. Additional protectiveness is to be achieved by implementing institutional control measures at the site, as specified in the May 2000 Institutional Controls Plan.

Because contaminants will remain in the groundwater at levels above the criteria for drinking water and for protection of the adjacent marine resources, LTM at this area is

required. As specified in the ROD, continuous groundwater monitoring will be conducted at Area 8 to determine the effectiveness of the soil removal, establish contaminant trends over time, and assess whether institutional controls restricting groundwater use for drinking can be discontinued. The monitoring data will be compared with federal and state drinking water standards for metals and VOCs. The groundwater monitoring data will also be compared with the LTM results for sediments and tissues to establish whether chemical migration in the groundwater from Area 8 is impacting the marine environment and to determine the need for groundwater control actions.

LTM will include sampling sediment and tissues that may be impacted by groundwater discharges from Area 8. As natural restoration continues at Area 8, residual contamination may continue to be discharged into Liberty Bay. Sediment and tissue monitoring will be conducted to assess if these discharges accumulate over the long-term and if they cause impacts on Liberty Bay that may warrant implementation of groundwater control measures.

The intent of institutional controls is to reduce the human health risk at the site to acceptable levels by preventing human health exposure to contaminants remaining at the site.

3. Current Status

This section describes the status of the selected remedies since the issuance of the RODs for OUs 1 and 2. The status is described for response actions (remedial actions and monitoring programs) that are in progress or have been completed with hazardous materials left in place. RODs, status reports, remedial action reports, and closure reports for the two OUs contain the details and status of the remedial actions. Remedies for each OU remain protective. There are no new ARARs that call into question the protectiveness of the remedies. There is also no new technology that would affect the selected remedies, or call into question the protectiveness of the remedies.

3.1 Operable Unit 1

Response actions that include phytoremediation of hot spots at the landfill, landfill cap maintenance, institutional controls, and LTM (phytoremediation, intrinsic bioremediation monitoring, and risk compliance monitoring) are ongoing. PCB-contaminated sediment removal and an upgrade to the tide gate was completed in 1999. No contingent actions for off-Base domestic wells are needed at this time.

3.1.1 Phytoremediation

Phytoremediation using two plantations of hybrid poplar trees was implemented in spring 1999 as the remedy for groundwater contamination at OU1. The goal of phytoremediation is to utilize the soil moisture uptake capability of the hybrid poplar trees to remove and treat VOC-contaminated groundwater, thus reducing the long-term potential for VOC migration (TCE-family) from the site. The remedy was implemented in accordance with the ROD. The two plantations are located at two high-VOC concentration source areas (hot spots) within the landfill. Tree planting began in April 1999, and by June 1999, planting and construction activities (e.g., irrigation system implementation, fencing, fertilization, etc.) of the two plantations were completed (URS et al., 1999).

The north and south plantations are both approximately 1 acre in size, and are located in the two hot spots identified in the RI/FS. Site construction work for the two plantations included establishment of the plantation boundary locations; asphalt and fencing removal; storm drain relocation; curb and new fence construction; landfill surface preparation and debris removal; placement of planting soil and soil amendments; installation of 3 wells (MW1-41 and 2 irrigation wells), 20 piezometers, and 2 lysimeters; installation of irrigation systems at both plantations; and planting the hybrid poplar trees. Landfill debris and soil removed during plantation construction were sampled, characterized, and recycled or disposed of at appropriate facilities.

During tree planting, the site soil was plowed to loosen the soil, and dormant hardwood cuttings of the hybrid poplars were planted at 6-foot intervals. A total of 545 trees were planted at the north plantation, and 360 trees were planted at the south plantation. A summary of the construction activities, specifications for onsite equipment, and as-built

drawings are included in the Phytoremediation Closure Report (URS et al., 1999). Figure 3-1 shows a simplified layout of the two plantations.

During the first growing season (summer of 1999), an extensive performance monitoring program and nurturing activities were initiated for the phytoremediation program. Detailed descriptions of these activities are found in the phytoremediation status reports (URS et al., 2000a, b, and c). The monitoring program included the following tasks:

- Application of irrigation based on the soil moisture content
- Operation and maintenance of the irrigation system
- Collection and analysis of soil, groundwater, surface water, and vadose-zone water samples
- Collection of depth-to-groundwater data and preparation of groundwater surface contour maps
- Poplar tree maintenance, including replanting trees that failed to sprout or died
- Fertilization and weed control

Overall, results were consistent throughout the first growing season. Surface and groundwater sampling results are described in Section 3.1.5. Vadose-zone water monitoring was conducted throughout the first growing season; water samples collected with the lysimeters. Because of the limited quantity of water extracted from the soil, there was only enough sample volume to test for VOCs and metals. A wide range of VOCs were detected from the vadose-zone water samples, although their concentrations were relatively low.

The irrigation system was maintained and operated throughout the first growing season. Because the irrigation wells did not provide sufficient quantities of contaminated water for irrigation, they were discontinued at the end of August 1999, and only potable water has been used for irrigation since September 1999. Contaminated water sampling was therefore eliminated from the monitoring requirement.

The results of the monitoring program were compared to the following performance standards to gauge the effectiveness of the phytoremediation program: (1) tree health; (2) groundwater flow; and (3) contaminant concentrations. Detailed descriptions of the results are found in the phytoremediation status reports (URS et al., 2000a, b, and c). The following sections summarize the performance criteria evaluation for the first growing season.

Tree Health

The overall health of the trees remained good during the first growing season and the dormant season as stated in the latest status report (URS et al., 2000c). The unusually cool, wet summer retarded tree growth slightly. Trees in the south plantation remain, on average, shorter with fewer leaves compared to the north plantation. The magnitude of these differences does not indicate significantly poorer performance in the south plantation.

Trees in the north plantation in the area of the temporary wood-chip haul road remained stunted during the growing season because of a nitrogen deficiency, despite the repeated

addition of nitrogen-rich fertilizers. It is expected this problem will be rectified after the wood chips have completely decayed.

Trees in the northeast quarter of the north plantation are suffering some stress because of oversaturated soil conditions. This condition will be remedied by modifying the drainage system at that location before the second growing season begins.

Weed growth has been considerable and will require continuous control to minimize competition.

The groundwater flow direction and gradient beneath both plantations are generally consistent with historical findings. The analysis of depth-to-groundwater data does not show any effect on groundwater flow patterns as a result of phytoremediation. No effect is expected before the trees mature.

Contaminant Concentration Trends

Contaminant concentration trends from selected groundwater wells at or near the two plantations were analyzed by comparing the 1999 first growing season data with historical data from 1995 through 1998. This was described in the August-October 1999 Phytoremediation Status Report (URS et al., 2000b). In general, contaminant concentrations do not exhibit a strong upward or downward trend at either plantation. Contaminant concentrations are generally within the range typically found in this area during past sampling events. Contaminant concentrations in the seep sample were found to have decreased to below the detection limit for all three target VOCs, although the correlation between the seep results and the phytoremediation progress was not clear.

Since the poplar trees were planted in spring 1999, they are not expected to affect the current site conditions until the third season (2001), when the root systems of the trees will reach the contaminated groundwater. Beginning in 2001, some indications of contaminant uptake and possible remedial effects such as transpiration from the trees may be found through phytoremediation sampling and monitoring, as the root systems begin to draw from the contaminated groundwater table.

3.1.2 Intrinsic Bioremediation Monitoring

As described in the 1997 Summary Data Assessment Report (SAIC and URS, 1997) and the 1998 ROD for OU1 (URS, 1998), groundwater redox conditions at the site appear to be generally favorable for complete degradation of chlorinated VOCs into their harmless byproducts—carbon dioxide, water, and chloride. The favorable conditions identified are strongly reducing groundwater beneath the source area (which is favorable for reductive dechlorination of TCE and some dichloroethene [DCE]), followed by mildly reducing groundwater downgradient of the source area (which is favorable for direct oxidation of DCE and vinyl chloride). Because phytoremediation activities could potentially affect redox conditions at the site, the ROD specified that performance monitoring should include the redox conditions beneath the plantations to check for potential adverse effects due to phytoremediation.

Redox conditions at OU1 were monitored during October 1998 (prior to pavement removal in the tree planting areas) and June 1999 (6 months after pavement removal and 2 months

after tree planting), in addition to the three previous pre-ROD sampling rounds in September 1996, April 1997, and March 1998. The monitoring involved analyzing groundwater samples from selected wells and piezometers for redox-sensitive constituents. The complete sampling methods and results and an interpretation of the data are currently being documented by the U.S. Geological Survey (expected to be published in summer 2000). A summary of the performance monitoring sampling results is provided below.

The sampling results indicate that although redox conditions have shown some variation between sampling rounds, the overall pattern of strongly reducing groundwater in the shallow aquifer beneath the landfill, followed by predominantly mildly reducing conditions downgradient of the landfill has remained consistent through June 1999. The data indicate that removing pavement and planting trees in the two plantation areas did not have a discernable effect on redox conditions after the first groundwater recharge season.

Within the shallow aquifer beneath the landfill, groundwater has been consistently anaerobic (dissolved oxygen less than 1 mg/L) during all sampling rounds through June 1999. As indicated by H_2 concentrations greater than 0.8 nM/L, groundwater in the vicinity of wells MW1-4, MW1-15, and MW1-16 has been predominantly strongly reducing. Comparing the pre-phytoremediation data (1996-98) to the post-phytoremediation data (June 1999) suggests that the pavement removal has had no significant effect on redox conditions beneath the poplar plantations. June 1998 monitoring well data were augmented with data from newly installed piezometers within the plantations. Results indicate that strongly reducing groundwater predominates beneath both plantations, and that very strongly reducing groundwater (H_2 > 5 nM/L) lies beneath the center part of the south plantation.

Intermediate aquifer groundwater upgradient of the landfill (MW1-33), first sampled during June 1999, was aerobic. Intermediate aquifer groundwater at the downgradient margin of the landfill (wells MW1-25 and MW1-28) was predominantly mildly reducing (H_2 concentrations 0.3 to 1.0 nM/L) from September 1996 through October 1998. Those wells were not sampled during June 1999. Intermediate aquifer groundwater downgradient of the landfill at Highway 308 (wells MW1-37 and MW1-39) has shown some variability in redox conditions between 1996 and 1999, from mildly reducing (1996 and 1998 sampling rounds) to strongly reducing (1997 and 1999 sampling rounds).

The redox conditions, in combination with the observed low concentrations of chlorinated VOCs at the furthest downgradient well MW1-39, illustrate that most of the intermediate aquifer contamination is being completely degraded to harmless byproducts within the aquifer itself. The low concentrations of chlorinated VOCs that are not degraded before reaching MW1-39 do not present a risk to human health because local hydrogeologic conditions prevent the contaminated groundwater from flowing beneath land areas downgradient of the landfill. Intermediate aquifer groundwater from the landfill flows toward the middle of the tide flats and Dogfish Bay, where it ultimately discharges to surface water. Once in the surface water, any remaining chlorinated VOCs are volatilized into the atmosphere, where they are rapidly destroyed by photo-oxidation reactions.

3.1.3 PCB-contaminated Sediment Removal

PCB-contaminated sediment removal, replacement of the damaged culvert, and the tide gate upgrade were completed in 1999 (Foster Wheeler, 1999a). The sediment removal action is aimed at decreasing the amount of PCBs found in the marsh sediments, thereby reducing the potential for PCBs to cause unacceptable risks in the future. The task of the sediment removal remedy was to remove approximately the top 6 inches of surface sediments from the area of the marsh downgradient of the landfill seep (Figure 3-2), where previous sampling had shown the highest PCB concentrations. PCBs were the target COCs that exceeded the sediment quality standards in the Washington State Sediment Management Standards (SMS), indicating potential adverse effects on biological resources at this location. Although the PCB levels were below levels requiring active cleanup, this remedial action was needed to reduce the potential for PCBs to move into the tideflats and Dogfish Bay and to accumulate in harmful quantities in the future. To minimize disruptions and short-term impacts on the marsh (as indicated in the ROD), a high-pressure vacuum truck was used with a suction line for vacuuming the sediment directly from the marsh into sludge boxes (heavily reinforced roll-off boxes suitable for transporting material having high moisture content). Prior to sediment removal, grade stakes were set on a 10-foot grid throughout the marsh to establish control over the depth of removal. A small tiller was used as needed to loosen the sediment and organic matter before vacuuming. Overall, approximately 75 tons of sediment was removed from the site, and transported to a Subtitle D landfill for solidification and disposal.

No additional sampling was conducted during the sediment removal action, and future sampling will be conducted as part of the LTM program to establish new baseline PCB concentrations in the area from which sediment was removed. LTM will include periodic sampling to monitor PCB concentration trends in the sediment.

3.1.4 Tide Gate Upgrade

The tide gate was completed and fully operational by November 1999 (Foster Wheeler, 1999a). The intent of upgrading the existing tide gate was to improve the control of tidal flow between the tide flats and the marsh, thereby ensuring that the landfill is protected from extreme tidal action that could flood its surface, erode its banks, or adversely affect the groundwater level within the landfill mass. The existing flap gate was replaced with a new tide gate. In order to provide adequate support to the new tide gate system, a reinforced concrete collar was constructed at the downstream end of the existing culvert adjacent to the tide flats, and a new 36-inch reinforced concrete culvert was installed to replace the existing corrugated metal pipe, which was in poor condition. During culvert installation, soil that was unsuitable as bedding material and embankment material for the new culvert was excavated and disposed of along with the excavated sediment. Crushed, recycled concrete was laid down as bedding material for the pipe and the culvert. A similar concrete collar was installed at the upstream end of the culvert which was furnished with a security grate to prevent unauthorized entry to the facility via the culvert. A new Waterman/Nekton self-regulating tide gate was then installed to replace the original flap gate.

3.1.5 Long-Term Monitoring

The overall objective of the LTM program is to monitor trends in chemical concentrations and evaluate whether the selected remedy meets remedial action objectives, while remaining protective of human health and the environment. Compliance with the remediation goals will be determined by comparing the monitoring results to the remediation goals for the points of compliance described in the ROD. If results from the LTM program indicate COC levels above the remediation goals, institutional controls and some degree of LTM will continue to be implemented at the site. If the remediation goals have been met for one or more of the monitored media in the future, the Navy and Ecology will decide if any components of the LTM and institutional controls can be discontinued.

The LTM program at OU1 involves periodic sampling of groundwater, surface water, seep, sediments, and marine tissue (clams). It also involves periodic measurement of water levels for the upper and intermediate aquifers to monitor the groundwater flow direction. The LTM program at Area 1 has three components: (1) monitor the effectiveness and trend of phytoremediation, (2) monitor the effectiveness of intrinsic bioremediation, and (3) assess risk and compliance of the remedial action.

The LTM program at OU1 began in 1999 when sampling of two deep water supply wells and groundwater sampling at and adjacent to the two phytoremediation plantations took place. These sampling efforts provided interim coverage of the LTM program, and are deemed appropriate for the first-year LTM program.

In June 1999, two water supply wells (one well on the base and one off-Base Public Utility District well) that are screened at the deep aquifer were sampled and analyzed for VOCs. No COCs were detected in the water samples.

The initial groundwater and surface water monitoring for phytoremediation was conducted in June 1999. The second round was conducted in October 1999. One surface water location, one seep location, and seven groundwater monitoring wells at and near the two plantations were sampled and analyzed for VOCs. The sampling results (along with results obtained during the previous investigations) are presented in Tables 3-1 and 3-2. Numerous VOCs (e.g., TCE and vinyl chloride) were found to exceed the remediation goals. When compared to previous sampling results, contaminant concentrations from the north plantation do not exhibit a strong upward or downward trend, and are generally within the range typically found during past sampling events.

In the south plantation, contaminant concentrations had apparently increased at wells MW1-4 and MW1-16, and at surface water station MA-12. At the same time, concentrations decreased at well MW1-5. At wells MW1-4 and MA-12, concentrations of TCE; cis-1,2-dichloroethene; and vinyl chloride were highest between 1995 and 1999. The initial round sampling results will be compared to future LTM results.

The LTM program for risk compliance will begin in 2000 as part of the newly implemented LTM program for OU1 sampling and analysis. Detailed descriptions of the LTM program for risk compliance are found in the LTM Project Work Plan (TEC LTM Team, 2000).

3.1.6 Landfill Cap Upgrade and Maintenance

The intent of this selected remedy is to upgrade and maintain existing landfill caps/covers to prevent direct human contact with waste materials and contaminated soil in the landfill, to limit the amount of rainfall that infiltrates into the landfill, and to allow the Navy to use portions of the landfill for parking and storage purposes. Part of the asphalt surface was removed for the construction of the two poplar tree plantations at the site (for phytoremediation). However, upgrading and maintenance activities have been minimal since the ROD was approved because repairs on the existing surface were not required. The 1999 soil sampling at the plantations (part of the phytoremediation monitoring, see Section 3.1.1), showed no significant contamination in the now exposed soil; therefore, removal of the asphalt surfaces at the two plantation locations was not expected to increase risk to human health from contact and ingestion. However, the effect of additional rainwater and irrigation water infiltration on the groundwater table, as well as the effect on VOC mobilization, will be assessed as part of the LTM program.

The Navy will continue to monitor the need for landfill cap upgrade and maintenance. The LTM data will be used to evaluate the functioning of the phytoremediation, intrinsic bioremediation, and risk compliance monitoring. These data will be used to adjust the extent of poplar planting zones, extent of asphalt pavement, and the need for upgrading and maintaining other capping surfaces on the landfill in the future.

3.1.7 Institutional Controls

An Institutional Controls Plan was prepared and finalized on May 19, 2000, to address the requirements outlined in the ROD (URS et al., 2000d). The intent of the institutional controls is to prevent undue exposure to landfill contaminants in the future. The Institutional Controls Plan outlines administrative procedures and actions that will limit or prevent activities that could interfere with the remedial activities at the site. These controls will preclude installation of water wells at OU1 (except environmental [monitoring or remedial action] resource wells), and prevent development or activity that would disturb the landfill, tideflat, and the adjoining marsh and shoreline in a manner that could lead to unacceptable risks to human health. Recent site visits by the Navy Remedial Project Manager and the Washington Department of Ecology Project Manager confirmed that institutional controls are currently being met at this site.

3.1.8 Contingent Actions for Off-Base Domestic Wells

This selected remedy involves contingent actions to prevent drinking water risks if the LTM results show that off-Base domestic wells could become contaminated in the future.

Based on field data collected during the remedial investigation and the additional site characterizations of site geology and calculated groundwater flow, it is unlikely that contaminated groundwater will migrate to off-Base domestic wells. The supplemental testing and assessment at OU1 indicated the COCs leaving the landfill are currently constrained by site hydrogeology to discharge into the marsh, tide flats, and Dogfish Bay. COCs have not migrated to any of the off-Base domestic wells. As a result, no contingent action has been implemented for this Five-Year Review period.

With the current hydrogeologic situation, the groundwater does not appear to present a hazard to drinking water resources. It is apparent that hydrogeologic conditions would have to change before contaminated groundwater could migrate off-Base and impact the domestic water supply wells that are screened in the upper or intermediate aquifers.

Sampling results from the 1999 sampling event confirmed that the deep aquifer is free of contamination both on-Base and off-Base.

3.2 Operable Unit 2

Response actions that include monitoring programs and institutional controls at OU2 are ongoing. Remedial construction actions have been completed at Area 8. All remedial actions are operational and functional, as documented in the Final Post-ROD Groundwater Monitoring Report for OU2, Area 2, Fall 1999 (EA, 2000a) and Final Closure Report, Remedial Action, Area 8, Building 72 Plating Shop Demolition and Soil Hot Spot Removal (Foster Wheeler, 1999b). Institutional controls have been established and are being maintained to prevent exposure until cleanup goals are attained throughout OU2.

3.2.1 Area 2

The ROD requires that the nature and extent of COCs be further investigated at Area 2, and that a groundwater monitoring program be implemented to monitor VOC contamination in the upper aquifer and to check if VOCs are migrating from Area 2. The investigation uses a phased approach, with subsequent phases based on the results of previous investigations. Based on the ROD requirements, three new wells were installed at Area 2 to evaluate possible upgradient sources (wells 2MW-4 and 2MW-5) and downgradient migration (well 2MW-6). During well drilling and installation, one soil sample was collected from each of the three well borings, but no COCs (TCE or vinyl chloride) were detected in any of the soil samples.

Five rounds of groundwater monitoring were conducted at Area 2 from 1995 through 1999 (annual sampling), and all groundwater samples were analyzed for VOCs. A summary of TCE and breakdown products detected in groundwater at Area 2 from 1995 to 1999 is listed in Table 3-3).

During the first round of groundwater sampling conducted in fall 1995, samples were collected from wells 2MW-1, 2MW-3, 2MW-4, 2MW-5, and 2MW-6 (EA, 1997a). TCE was detected in samples from four wells, with two exceeding the groundwater remediation goals (at 2MW-1 and 2MW-5) (Table 3-3). Vinyl chloride was detected in samples from wells 2MW-3 and 2MW-6 at concentrations exceeding the remediation goals. After evaluating the results from the first round of sampling, three wells (2MW-1, 2MW-5, and 2MW-6) were selected to be sampled during subsequent sampling rounds (through 1999). Well 2MW-1 has the highest TCE detection level. Well 2MW-5 is the new upgradient well; 2MW-6 is the new downgradient well. TCE and vinyl chloride continued to be detected in the monitoring wells from round 2 through round 5.

The ranges (minimum and maximum) of VOCs detected in groundwater at Area 2 in all five rounds of groundwater monitoring are generally on the same order of magnitude compared to those found in the remedial investigation, although results from the 5 years of monitoring

indicate a slight declining trend of the VOC (especially TCE) concentrations found in the upper aquifer (Table 3-4). TCE in well 2MW-1 decreased from 40 µg/L in 1995 to 17 µg/L in 1999, while TCE decreased in the background well 2MW-5 from 11 µg/L in 1995 to 0.4 µg/L. This trend is also true for vinyl chloride.

The first 5 years of data indicated that the VOC plume continues to be present in the upper aquifer under Area 2 amid a declining trend, although there is no indication of increased downgradient migration (decrease of VOC concentrations in the downgradient well 2MW-6) of VOCs (EA, 2000a). An LTM program is being implemented at Area 2 to continue monitoring VOC contamination. Because upgradient well 2MW-5 has had VOC concentrations below the remediation goals since 1996, it will be dropped from sampling during the LTM program. An additional monitoring well (MW2-6, which is north and west of 2MW-6) will be added to the LTM program to better assess the downgradient condition of the groundwater quality at Area 2.

An Institutional Controls Plan was prepared and finalized on May 19, 2000, to address the requirements outlined in the ROD (URS et al., 2000d). The plan includes: (1) prevention of future residential land use; (2) control of physical access to the site; (3) prevention of well construction and groundwater use except for environmental monitoring and future remedial purposes; and (4) restriction of future construction activities at Area 2 and implementation of preventive measures restricting future intrusive construction activities at the area (e.g., soil excavation). Recent site visits by the Navy Remedial Project Manager and the Washington Department of Ecology Project Manager confirmed that institutional controls are currently being met at this site.

3.2.2 Area 8

The selected remedies outlined in the OU2 ROD for Area 8 have been implemented during this first Five-Year Review period. The removal of the vadose zone soil hot spots was accomplished during the demolition of Building 72, the former plating shop. Groundwater monitoring has been conducted since fall 1995. The ROD specified two rounds of sediment and tissue sampling for the first Five-Year Review. The first round of sediment and tissue sampling was conducted in 1996. The second round is scheduled to be conducted in June 2000. This Five-Year Review does not include the results of the second round of sampling.

Vadose Zone Soil Hot Spot Removal and Building 72 Demolition

Building 72, the former plating shop, was demolished in 1999 after industrial operations were transferred to the new plating shop at the facility. Building 72 demolition was accompanied by soil removal at hot spots delineated during the RI/FS and specified in the OU2 ROD. The soil hot spot removal remedy involved excavating soil contaminated with cadmium and chromium to 9 feet bgs. Hot spot areas were defined as areas with cadmium and chromium concentrations exceeding state MTCA Method B cleanup levels for soil ingestion, which are 80 mg/kg for cadmium and 400 mg/kg for chromium.

Extensive sampling programs were implemented for the Building 72 demolition and hot spot removal to delineate and characterize the nature of soil contamination at Area 8 for proper soil removal and disposal. A preliminary sampling and analysis program was conducted in 1996, which included perimeter soil sampling and soil sampling under the

building. Sampling results indicated the presence of TPH-contaminated soil but no soil contamination from plating operations beyond the perimeter of Area 8.

A delineation sampling program was conducted as part of the Building 72 demolition and hot spot removal. The program was implemented in three phases from April 1998 through January 1999, with subsurface soil sampling by soil borings located on a grid setting across the site. Samples were collected from selected intervals based on the requirements of the Remedial Action Work Plan (Foster Wheeler, 1997), and were analyzed for total metals, VOCs, semivolatile organic compounds (SVOCs), and TPH-diesel. Overall, a total of 107 soil borings were drilled, and 78 of the 107 borings were used for soil characterization under the ROD. The rest of the borings were used for TPH-diesel characterization. The results were used to identify contaminated areas for subsequent removal. TPH removal actions and demolition were conducted at Buildings 181 and 804 (Foster Wheeler, 1999b, 2000a). Results of the subsequent independent remedial actions for diesel contamination are described in separate Remedial Action Closure Reports for TPH removal and demolition at Building 181 and Building 804 (Foster Wheeler, 1999b, 2000a).

Detailed discussions of the delineation program and sampling results can be found in the Final Closure Report for Building 72 demolition and hot spot soil removal (Foster Wheeler, 1999b). In general, seven ROD inorganics and 19 organic compounds were detected in subsurface soils during the delineation program. Of the seven detected inorganics, only cadmium (6 locations) and chromium (3 locations) exceeded the ROD action levels. The delineation sampling results were used to define the hot spot areas, as shown in Figure 3-3.

The soil hot spot removal action was conducted in two phases in July 1998 and March 1999. In accordance with the ROD, cadmium and chromium contaminated soil was removed to groundwater level at 9 feet bgs. The hot spots identified during the delineation sampling are shown in Figure 3-3. The hot spot areas were excavated and backfilled with imported granular material the same day. Contaminated soil was transported and disposed of at Waste Management, Arlington. Overall, 1,100 tons of metal-contaminated soil were excavated from the hot spot areas and properly disposed of.

Groundwater Monitoring

Groundwater monitoring has been conducted by sampling multiple monitoring wells screened at the upper aquifer at Area 8. Most of the wells sampled were screened at the uppermost portion of the aquifer to monitor horizontal migration. Two wells (MW8-15 and MW8-16) were screened below the depth of known contamination to monitor for possible downward migration.

Four new groundwater monitoring wells were installed in 1995 to support the post-ROD groundwater monitoring program. During the first round of post-ROD groundwater monitoring at Area 8 (fall 1995), 12 monitoring wells were sampled for VOCs, inorganics, and SVOCs. The numbers of wells to be sampled were reduced to six in subsequent rounds and SVOCs were no longer included for analysis. Overall, nine rounds of groundwater sampling were conducted at Area 8 between 1995 and 1999, and their summary results (including seep samples) are shown in Tables 3-5 and 3-6. As indicated in these tables, TCE was the most widely detected VOC compound in the groundwater samples, and the detected concentrations exceeded the drinking water remediation goal on most occasions.

Dissolved cadmium and chromium were also detected in groundwater samples that consistently exceeded the remediation goals. Figures 3-5 and 3-6 show the VOC and inorganic detections and trends in selected groundwater monitoring wells throughout Area 8.

The ranges of COC concentrations detected in groundwater at Area 8 during the post-ROD monitoring were generally similar to the remedial investigation results, but the remedial investigation concentrations were usually slightly higher (Table 3-7) (EA, 2000b). These results suggest a downward trend in groundwater concentrations of COCs at Area 8. This downward trend also indicates that the recent soil removal activities have not mobilized significant quantities of contaminants at the site. More detailed trend analyses using best bit trend lines on long-term data sets from selected groundwater monitoring wells also indicated that the COC concentrations in the groundwater are, with few exceptions, decreasing (EA, 2000b). Overall, these 9 rounds of sampling over 4 years have shown a slightly decreasing trend in concentrations of cadmium, chromium, and VOCs. The fall 1999 round, conducted just prior to completion of the remedial excavation, did not indicate any additional contaminants had been released to the groundwater. In conclusion, results from the fall 1999 monitoring showed little change in the groundwater COC concentration trends since the remedial action was completed at Area 8.

TPH contamination in groundwater will be included in the LTM monitoring program for groundwater and seeps because of the TPH removal action at Buildings 181 and 804.

Sediment and Tissue Sampling

One round of sediment and tissue sampling was conducted in May 1996. Sampling stations were located relative to the intertidal seeps as shown in Figure 2-4. Three transects were laid on the beach, with two of them centered on the seeps and one located between the two seeps. Three stations at various elevations were located on each of the transects for a total of nine stations at the site. Three stations at the reference site immediately south of NUWC Keyport were also located and established by Global Positioning System, and sampled along with the site stations.

Sediment samples from 0 to 10 cm from the beach surface were collected at each of the sample stations. Littleneck clam (*Protothaca staminea*) was the shellfish species collected for analyses.

Marine sediment samples were analyzed for VOCs, SVOCs, polycyclic aromatic hydrocarbons (PAHs), total organic carbons, pesticides, chlorinated organics, cyanide, and metals. Grain size analyses were performed on marine sediment samples. Tissue samples were analyzed for SVOCs, PAHs, organophorous pesticides, chlorinated organics, cyanide, metals, and hexavalent chromium.

The analytical results of the sediment and tissue samples are listed in Tables 3-8 and 3-9. Detailed statistical comparisons of the sediment and tissue sampling results to the SMS (sediment only), reference stations, and remedial investigation results are described in the Post-ROD Round Two Monitoring Report (EA, 1997b), and the statistical data are listed in Tables 3-10 and 3-11. Overall, no specific spatial relationships were observed between chemical concentrations found in sediments and tissues. There is also no apparent correlation of most chemical concentrations in sediments or tissues with the locations of the

two seeps. The sediment and tissue sampling results from the 1996 sampling round were also similar to the results reported in the remedial investigation studies.

Hexavalent chromium concentrations were elevated in seep water from Seep A, and in sediment and tissue samples from near the Seep A station, when compared to sediments and tissues from mid-zone and deeper intertidal stations. During the same sampling event, chromium and cadmium concentrations were both elevated in groundwater east of the plating shop in the direction of Seep A. These findings suggested a trend for chromium and cadmium from groundwater east of the plating shop to flow towards Liberty Bay and to discharge into Seep A, where it could subsequently affect the sediments and tissues located at and near Seep A. Concentrations of chromium and cadmium in sediment then follow a decreasing trend downgradient of Seep A to deeper intertidal stations and subtidal stations.

The second round of sediment and tissue sampling as specified in the ROD was conducted in early June 2000. Reference stations were not sampled because no bioassays were performed on the second round samples.

Groundwater Control

No groundwater control actions were initiated during this Five-Year Review period because only one round of sediment and tissue sampling was conducted, and because the sediment and tissue analytical results did not indicate the need for the evaluation. However, the ROD provides guidelines for groundwater control actions should the need arise.

The data collected from the Area 8 sediment and tissue monitoring program will be evaluated for human health risk using the same methodology and exposure assumptions as employed in the baseline risk assessment for Area 8. In addition, the sediment data will be evaluated for ecological risk by comparing the data results with the SMS cleanup screening levels. The details of this evaluation will be specified in the risk assessment (to be completed in the future). The shellfish tissue data will also be evaluated for ecological risk using the methodology employed in the baseline risk assessment, including effects to higher trophic level organisms (i.e., English sole, pigeon guillemot). If these evaluations show unacceptable risks or exceedances of state sediment cleanup screening levels, the Navy will initiate groundwater control actions or further investigations with input from the community and concurrence by EPA and Ecology, as required by the ROD.

Institutional Controls

An Institutional Controls Plan was finalized in May 19, 2000 (URS et al., 2000d) to address the requirements outlined in the ROD. The Institutional Controls Plan outlines administrative procedures and actions that will restrict residential land use at Area 8, prevent construction of potable wells, restrict construction activities, and provide for LTM activities. Control of physical access to the site was lifted after the soil hot spots were removed and the site was paved with asphalt. These institutional controls will be implemented and maintained while the Navy owns the property. The ROD also provides guidelines for property transfer of Area 8, should the Navy decided to transfer or sell the property to another owner in the future. Recent site visits by the Navy Remedial Project Manager and the Washington Department of Ecology Project Manager confirmed that institutional controls are currently being met at this site.

3.3 Site 23 Removal Action

The Navy performed a time-critical removal action at Site 23 under CERCLA as a part of the Building 21 demolition. The time-critical removal action was conducted under an Action Memorandum signed in July 1999. Although Site 23 was not included as one of the original sites to be investigated and was not included in the OU2 ROD, the results of this time-critical removal action are included in this Five-Year Review because the removal action was performed under CERCLA.

Site 23 includes Building 21, which was located in the industrial area of NUWC Keyport (Figure 3-4). Building 21 was constructed in the 1940s, and had been used to store lubricating oil and also housed a filtering system for petroleum-based machining coolants. Immediately east of Building 21 was an enclosed wash rack which had two 2,000-gallon tanks for collecting and storing waste lubricants and rinsates from the cleaning of equipment. Because of past practices at Site 23, it was suspected that contamination might be present in the soil underlying and surrounding Building 21. There were also unconfirmed reports that drums containing unspecified materials had been buried around Building 21.

The Building 21 demolition and soil removal action was conducted in September and October 1999. The results are described in detail in the Draft Closure Report (Foster Wheeler, 2000b). After the demolition of Building 21, soil excavation and removal was conducted in five areas delineated by the results of the previous investigations. The locations and depths of excavation of the five areas are shown in Figure 3-5. In general, TPH-contaminated soil was excavated from the center of each area to all four sides until field test results indicated the tested sidewall or bottom had less than 1,000 mg/kg TPHs. The bottom was excavated until the groundwater table was reached. Confirmation samples were then collected from the sidewalls and excavated bottoms of each of the five areas before backfilling with clean import fill. Excavated soil was transported to a temporary stockpile area located on the facility, sampled and characterized, and transported offsite to a low-temperature thermal desorption facility for treatment and disposal. Overall, 355 tons of soil were treated and disposed of at the offsite facility (Foster Wheeler, 2000b).

During soil removal at the disturbed areas (four areas suspected to contain buried drums were identified by the ground-penetrating radar/magnetometer survey), numerous cylindrical metal objects were found, but no drums.

A risk-based evaluation was conducted for the site to assess residual risks associated with petroleum contamination remaining at the site after the removal action (Appendix D, Foster Wheeler, 2000b). Based on the risk evaluation, the remaining risks at the site were demonstrated to be protective of human health and the environment with institutional controls.

The excavated site was backfilled and paved with 4 inches of asphalt concrete. This site is subjected to institutional controls and will be added to the Institutional Controls Plan.

4. Areas of Noncompliance

No areas of noncompliance were identified during this review.

All remedial activities conducted in OU1 and OU2 during this Five-Year Review adhered to the requirements outlined in the RODs. No activities were performed at either OU that were contrary to the selected remedies or otherwise would compromise the implemented remedies.

5. Recommendations

5.1 OU1 Recommendations

The remedies for OU1 remain protective of human health and the environment. Since the ROD for OU1 was signed in late 1998, most of the remedial alternatives have just been implemented. No significant modifications are proposed to the selected remedies outlined in the ROD, and ongoing remedial action and monitoring programs will adhere to the ROD requirements. The following recommendations are proposed for OU1:

- **Phytoremediation:** Continue implementing phytoremediation at OU1. The two plantations will be maintained and monitored during the second and subsequent growing seasons. Since the poplar trees were planted in spring 1999, they are not expected to affect the current site conditions until the third season (2001), when the root systems of the trees will reach the contaminated groundwater. During the third growing season, irrigation requirements will be reevaluated because the trees are expected to draw moisture from groundwater. At this point, some indications of contaminant uptake and possible remedial effects such as transpiration from the trees may be found through phytoremediation sampling and monitoring. Work scope, testing requirements, and field procedures will follow the Phytoremediation Work Plan (U.S. Navy, 1999).

- **Landfill Cap Upgrade:** The Navy will continue to monitor the need for landfill cap upgrade and maintenance in the future. The LTM data will be used to evaluate the functioning of the phytoremediation and intrinsic bioremediation, and these data will be used to adjust the extent of poplar planting zones, extent of asphalt pavement, and the need for upgrading and maintaining other capping surfaces on the landfill in the future.

- **Sediment Removal and Tide Gate Upgrade:** PCB sediment removal and tide gate upgrade were completed. The Navy will continue to monitor the contamination level in the sediment in the marsh area. This monitoring work will be conducted as part of the LTM program.

- **Long-Term Monitoring:** Implementation of LTM for assessing risk and compliance will begin in spring 2000. The scope, schedule, and detailed descriptions of the monitoring program between 2000 and 2004 are included in the LTM Work Plan (TEC LTM Team, 2000) and are summarized in Table 5-1. LTM for assessing risk and compliance will follow the requirements specified in the ROD, with the following additional requirements agreed upon between the Navy and Ecology:

  - The spring 2000 groundwater sampling will include four wells (2 well sets) located at the western boundary of the site: MW1-7, MW1-8, MW1-9, and MW1-10 for VOCs. The sampling is planned as a one-time-only event, aimed at checking if VOC contamination has migrated westward to the upper and intermediate aquifers.

  - Wells MW1-17 and MW1-41, which are screened at the upper aquifer, will be added to the LTM program and sampled annually for VOCs.

- **Annual Monitoring Report:** Prepare an annual monitoring report to summarize monitoring results and recommendations from the three LTM programs for OU1: phytoremediation, intrinsic bioremediation, and risk compliance. The annual monitoring report will be reviewed by Ecology and EPA.
- **Monitoring Data Review:** Continue to review monitoring data for trend and spatial analyses of VOC contamination in the upper and intermediate aquifers. This information will be used to determine if contingent actions are needed for off-Base domestic wells to reduce risk to drinking water at those wells.
- **Institutional Controls:** Continue to implement and maintain institutional controls as required by the ROD.

5.2 OU2 Recommendations

5.2.1 Area 2

All remedies for Area 2 remain protective of human health and the environment. During the second Five-Year Review period, groundwater quality will continue to be monitored by annual sampling at three wells. One change will be made—the upgradient well (2MW-5) will be eliminated from the monitoring requirement and replaced by another downgradient well (MW2-6) in order to provide a better understanding of the VOC plume migration. The existing Institutional Controls Plan will be used to implement and maintain the institutional control requirements for this site.

5.2.2 Area 8

All remedies for Area 8 remain protective of human health and the environment. The remedial construction activities have been completed for Area 8, and LTM and institutional controls are the only ongoing remedial activities prior to the next Five-Year Review. The monitoring requirements specified in the ROD will be implemented, with the following recommended modifications:

- **Groundwater Monitoring:** Continue the ongoing groundwater monitoring program for the six selected groundwater monitoring wells. An additional well screened at the deepest part of the upper aquifer (MW8-15) will be sampled once to verify that VOC contamination has not migrated downward to the deepest part of the aquifer.
- **Upgradient Wells:** The original plan called for sampling two upgradient wells (MW8-17 and MW8-18) after completion of the remedial action at Area 8. After discussions between Ecology and the Navy, these two wells were dropped from the monitoring list. Ecology and the Navy agreed to sample MW8-10 on a one-time-only basis for VOCs because it is near the former dangerous waste tanks.
- **Groundwater Sampling Frequency:** During the five-year post-ROD groundwater sampling (1995 through 1999), two rounds of groundwater sampling were conducted annually. Beginning in 2000, groundwater monitoring will be conducted once every year. Table 5-2 lists the sampling frequency and requirements of the selected wells.

- **Seep Related Sampling:** Two seeps discharging groundwater into Liberty Bay were sampled once in spring 1996 along with the sediment and tissue samples. The seeps will be sampled annually beginning in spring 2000.
- **Sediment and Tissue Sampling:** Two rounds of sediment and tissue sampling will be conducted prior to the next Five-Year Review period (2000 and 2004). No sampling will be conducted at the reference station because no bioassay will be done at the site stations. Analytical requirements for future sampling will be the same as for the previous sampling event (listed in Table 5-2).
- **Modifications:** This LTM approach may be modified, as needed, by mutual agreement between Ecology and the Navy.
- **TPH Sampling:** Although TPH remedial action at Area 8 has been completed as a MTCA independent remedial action, TPH monitoring will become part of the LTM program at Area 8 to monitor the state and condition of TPH contamination remaining at the sites. The following are the recommended tasks under this new monitoring program:
  - MW8-2 and MW8-9 will be sampled for TPH-heavy oil to monitor the effectiveness of the slurry wall in stopping the flow of TPH contamination, and to determine whether any TPH contamination has migrated past the slurry wall towards Liberty Bay.
  - Seep A, which is located on the beach directly downgradient of the former UST site south of Building 86, will be sampled for TPH-heavy oil. This sample station will be used to detect if any remaining TPH contamination at the former UST site has migrated and discharged to the beach area bordering Liberty Bay.
  - A physical check will be conducted in the beach immediately north of Seep A and east of Building 86 to observe if there is any physical evidence of TPH contamination. The physical check is only a qualitative approach used mainly to detect signs of TPH contamination that might have been associated with the potential release/discharge of TPH from the former UST site south of Building 86. The physical check will not determine the extent and origin of TPH on the beach. If TPH is observed, further assessment will be needed to confirm the origin and quantity of TPH contamination.
  - The cleanup goal for TPH contamination is set at 200 mg/L in groundwater, as described in the IRAP (Foster Wheeler, 2000a).
  - The above TPH monitoring components will be conducted in spring 2000 and spring 2004 before the next Five-Year Review. After the second round of sampling, the Navy and Ecology will determine if further monitoring is required.
- **Institutional Controls:** Continue to implement and maintain institutional controls as required by the ROD.

6. Next Five-Year Review

The next Five-Year Review will be completed by November 2005. This review will discuss the LTM programs for OU1 (Area 1) and OU2 (Areas 2 and 8), operation progress and results of the phytoremediation for OU1, and effectiveness of the institutional controls at Areas 1, 2, and 8. This review will also compare the LTM program results to the site remediation goals. Trend analyses for the various LTM programs will be conducted to assess the attainment of remediation goals, so decisions on whether to continue the LTM programs can be made in the next Five-Year Review.

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Figures and Tables

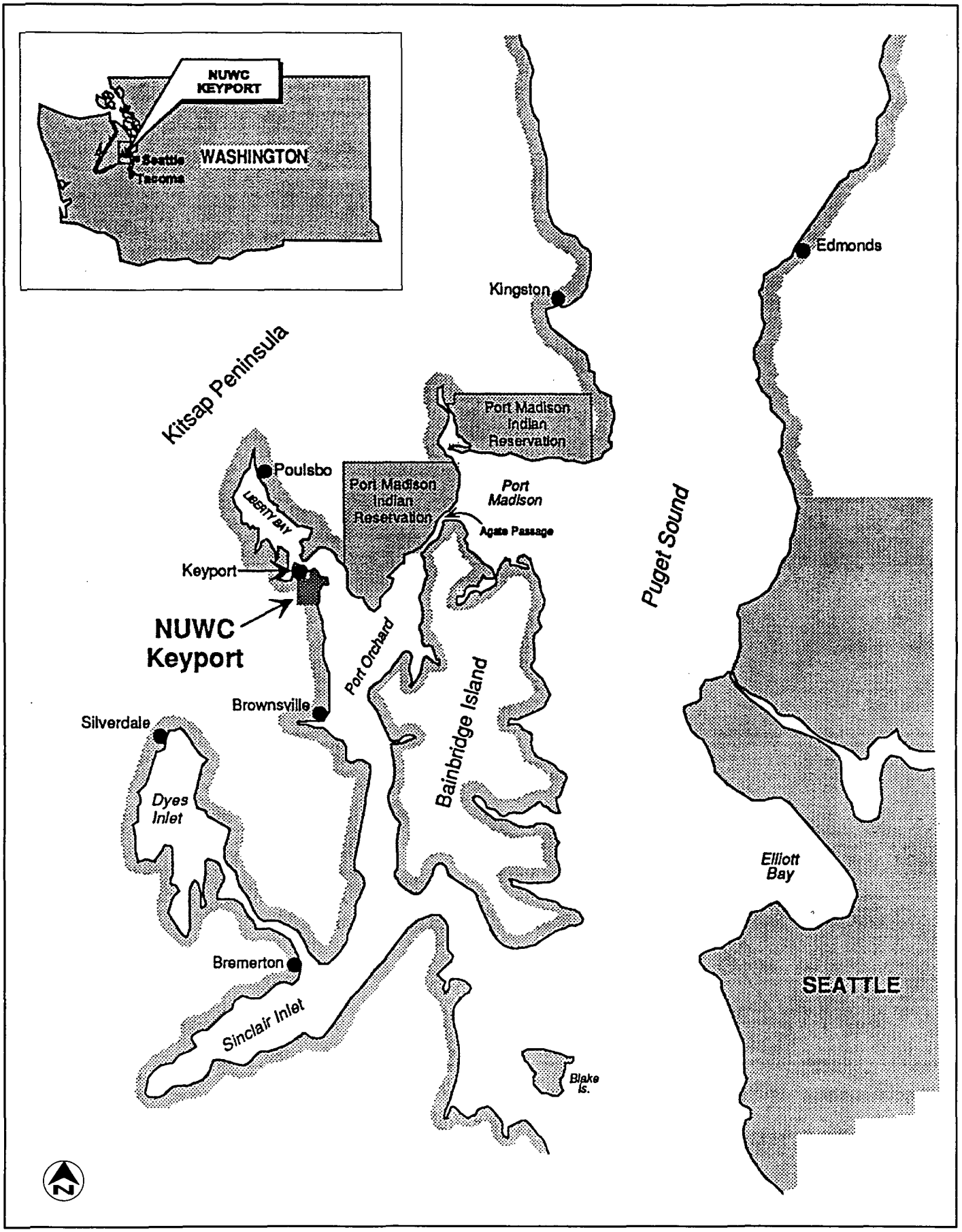


FIGURE 1-1
Location of NUWC Keyport

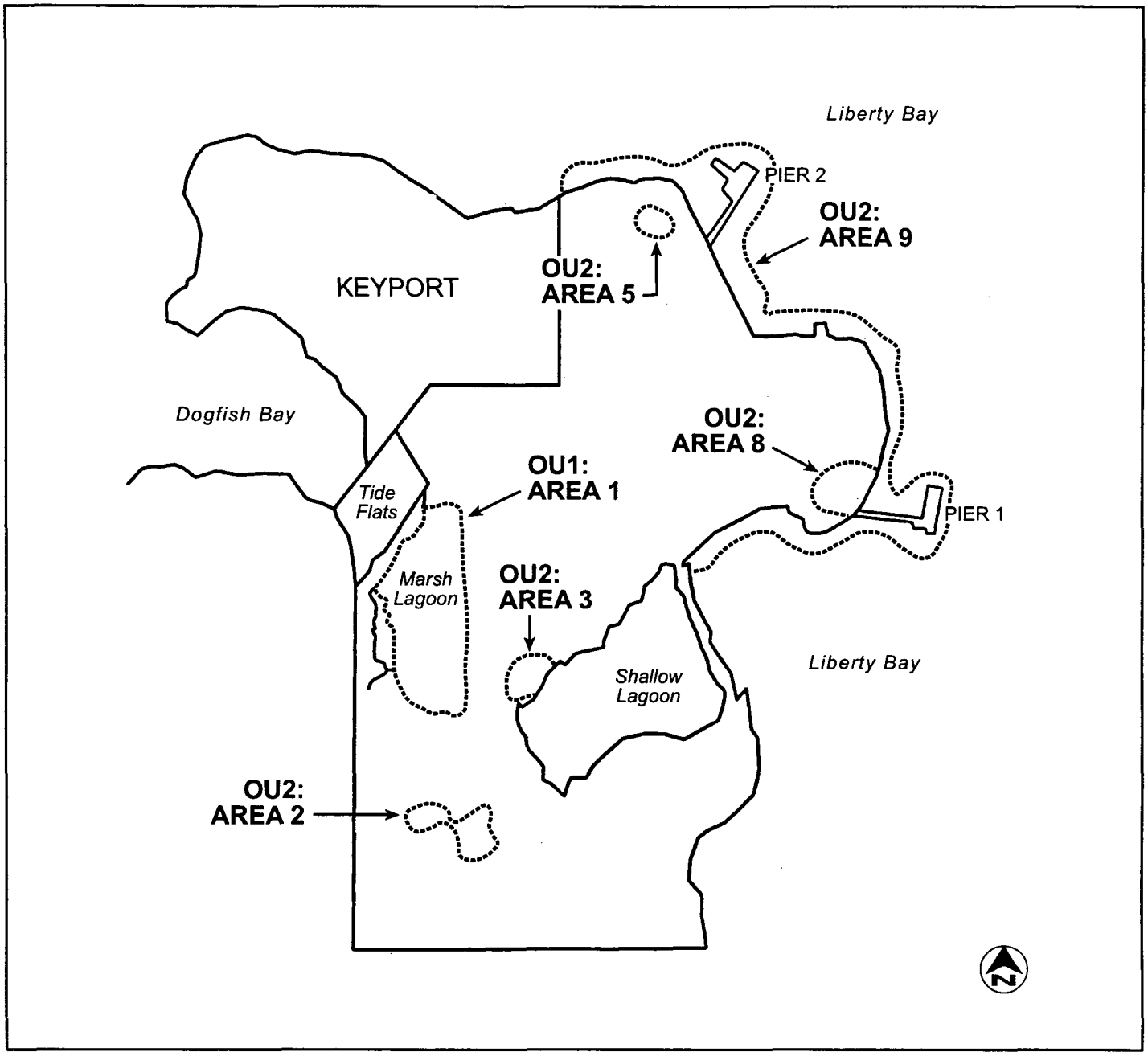


FIGURE 2-1
Locations of Areas 1, 2, 3, 5, 8, and 9
NUWC Keyport, Washington

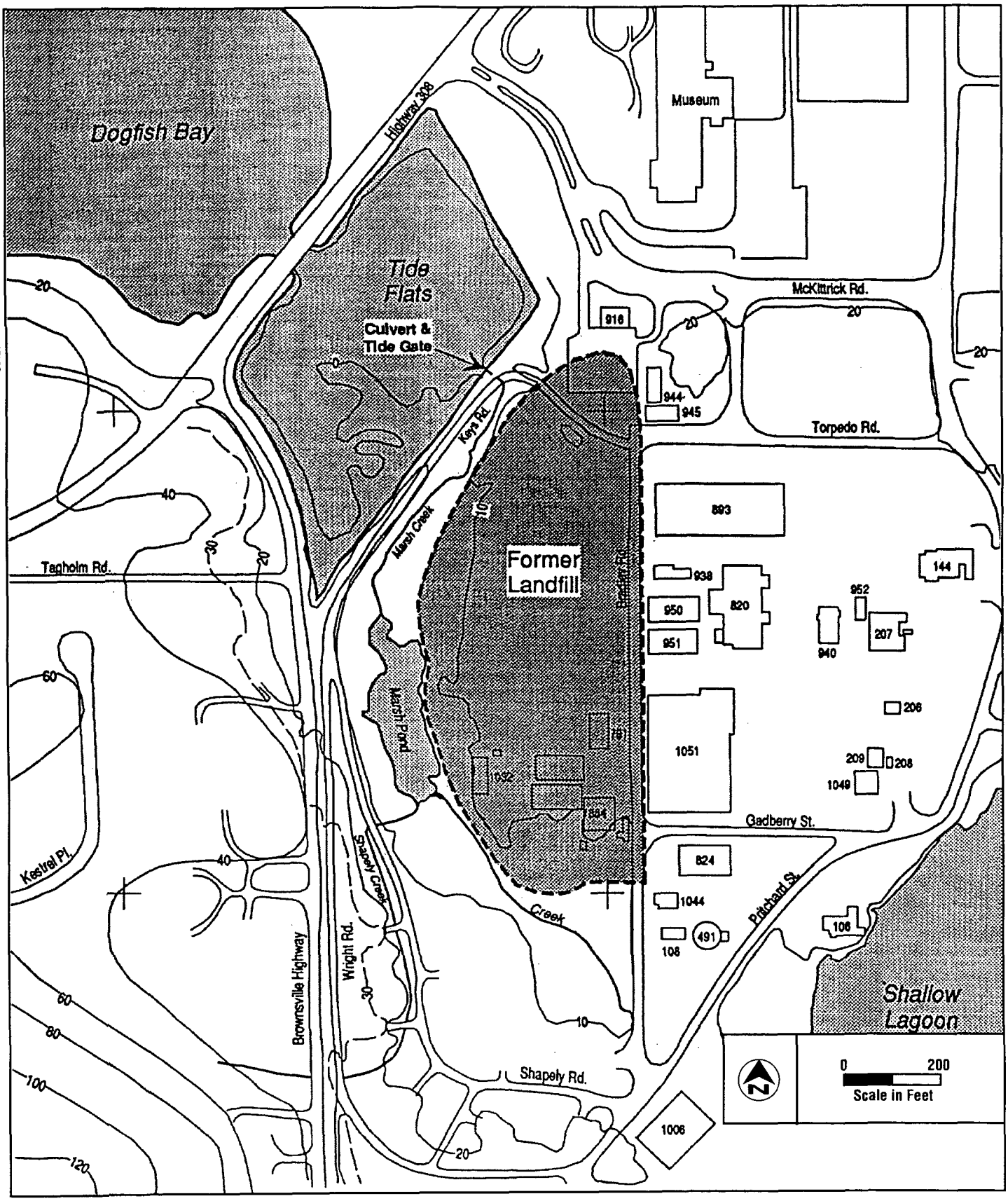


FIGURE 2-2
Site Location Map for Area 1
Former Base Landfill
NUWC Keyport, Washington

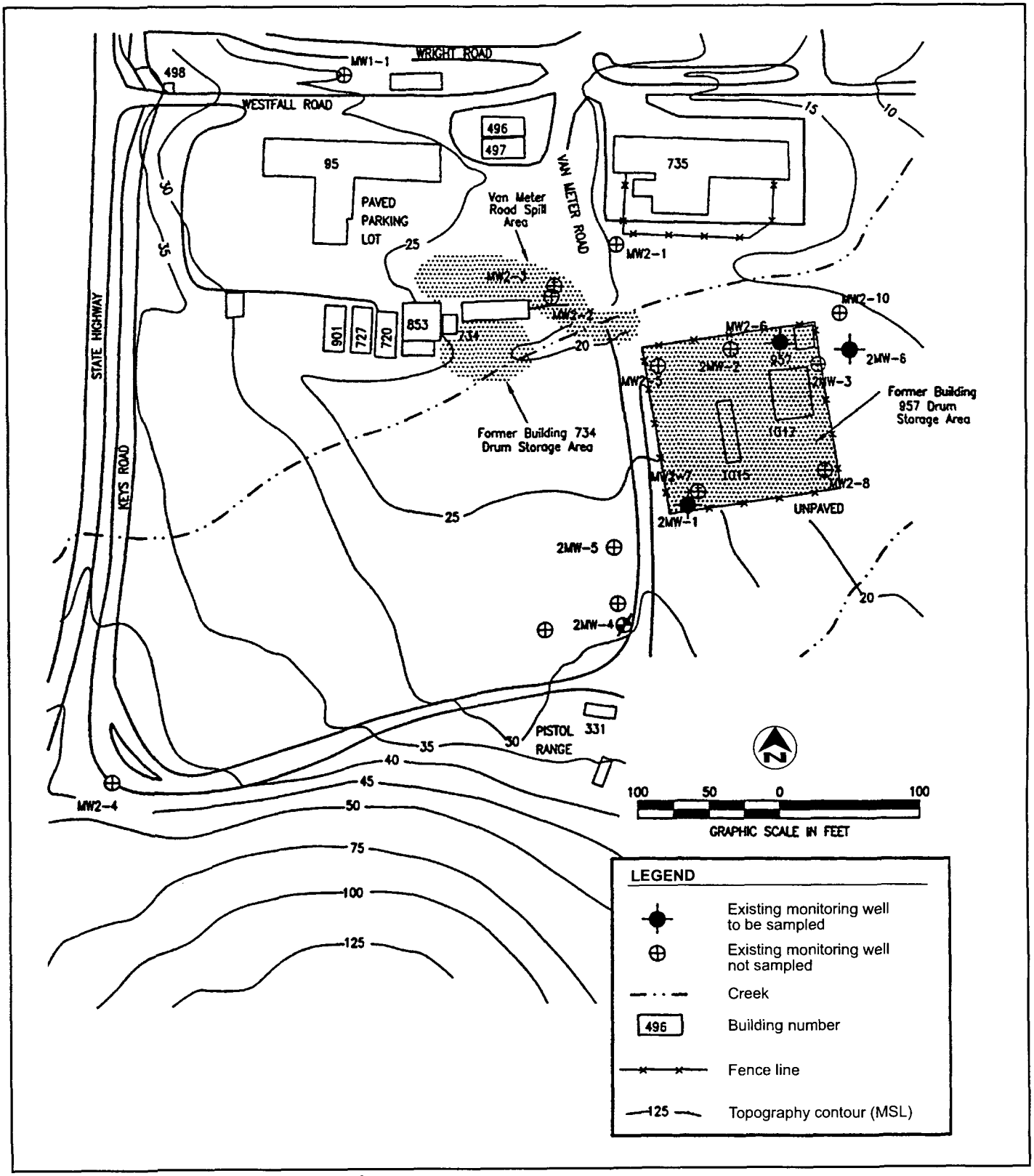


FIGURE 2-3

Area 2 Site Layout and Monitoring Well Locations

NUWC Keyport, Washington

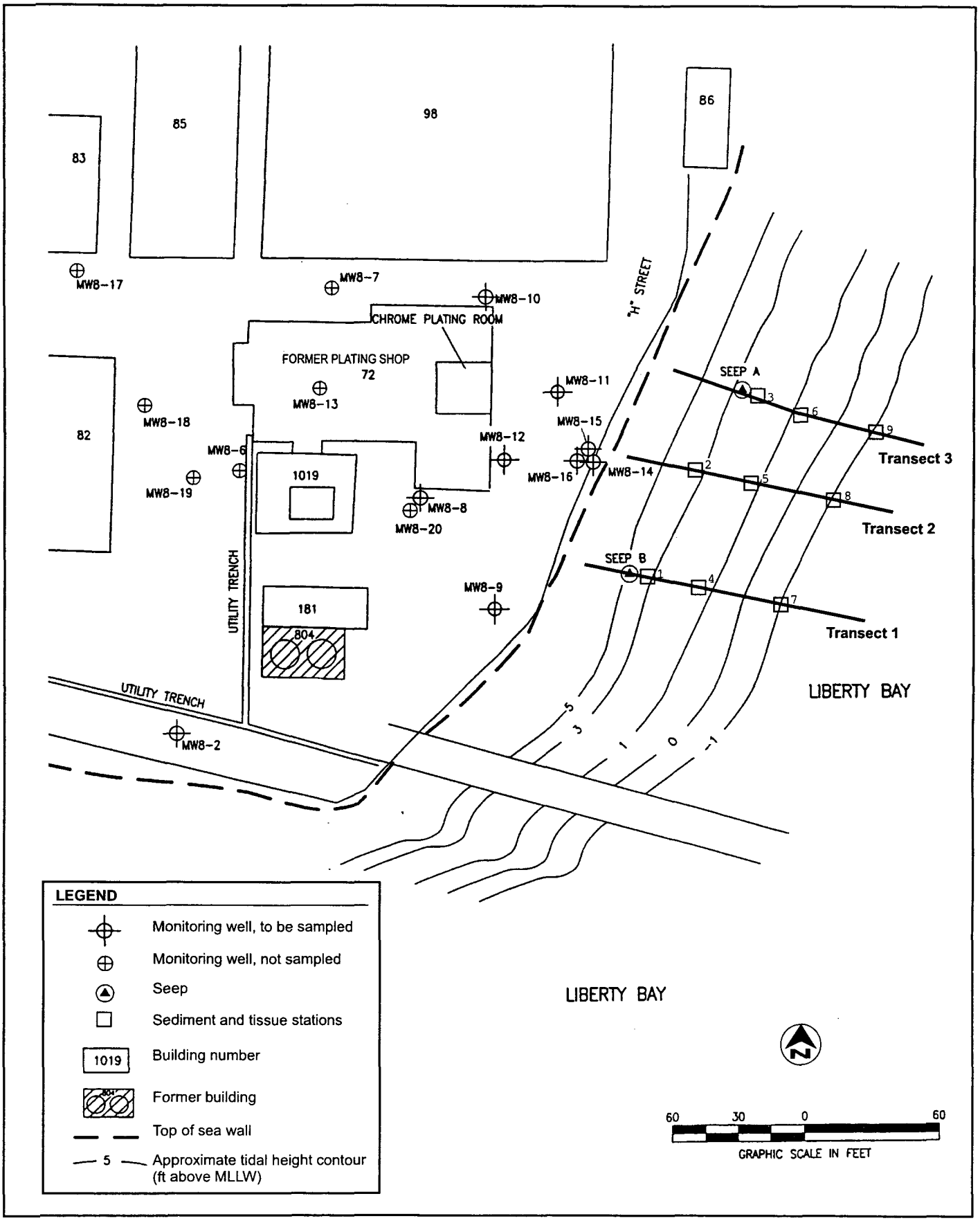
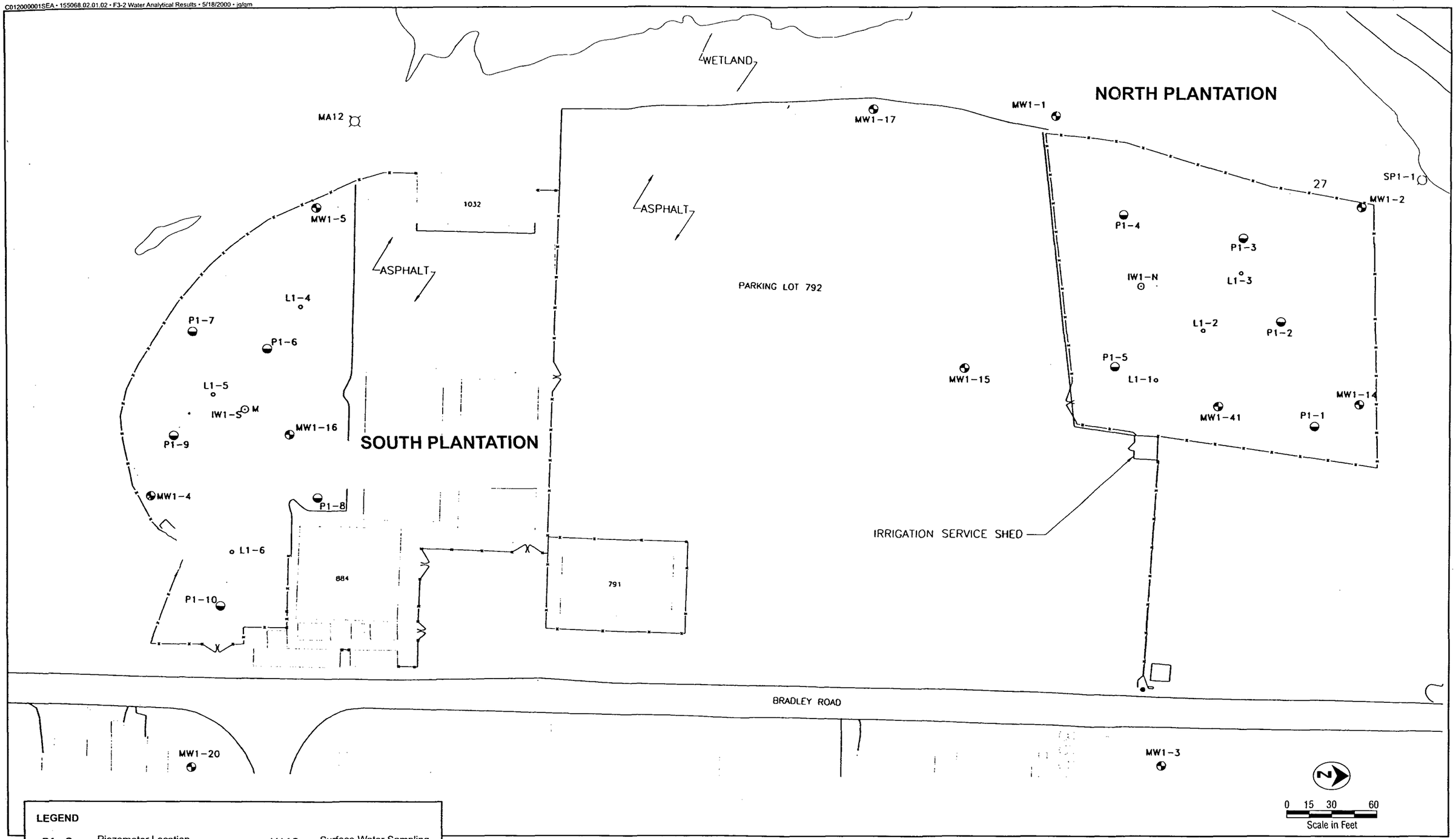


FIGURE 2-4

Area 8 Layout and Sampling Locations

NUWC Keyport, Washington



LEGEND

P1-2	Piezometer Location	MA12	Surface Water Sampling
IW1-N	Irrigation Well Location	SP-1	Seep Sample Location
MW1-2	Monitoring Well Location	L1-2	Lysimeter Location

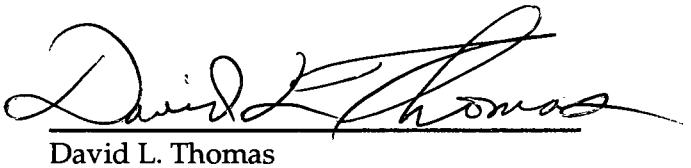
FIGURE 3-1

Site Layout for North and South Plantations for Phytoremediation at OU1

NUWC Keyport, Washington

7. Certification of Protectiveness

The Navy certifies that the remedies selected for NUWC Keyport remain protective of human health and the environment.



6/28/00

David L. Thomas
Captain, U.S. Navy
Commanding Officer
Naval Submarine Base, Bangor

Date

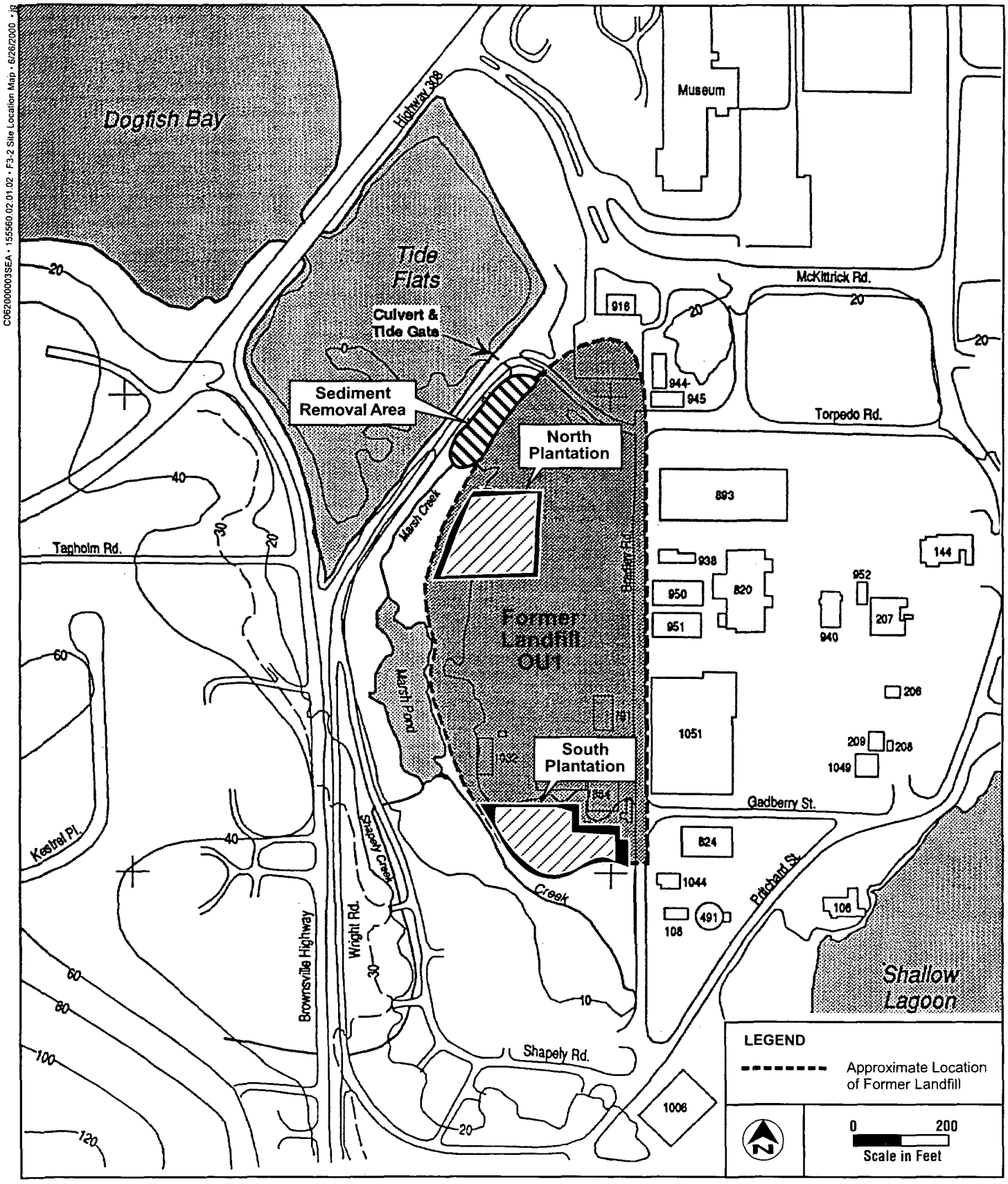


FIGURE 3-2
Area 1 Location Map
NUWC Keyport, Washington

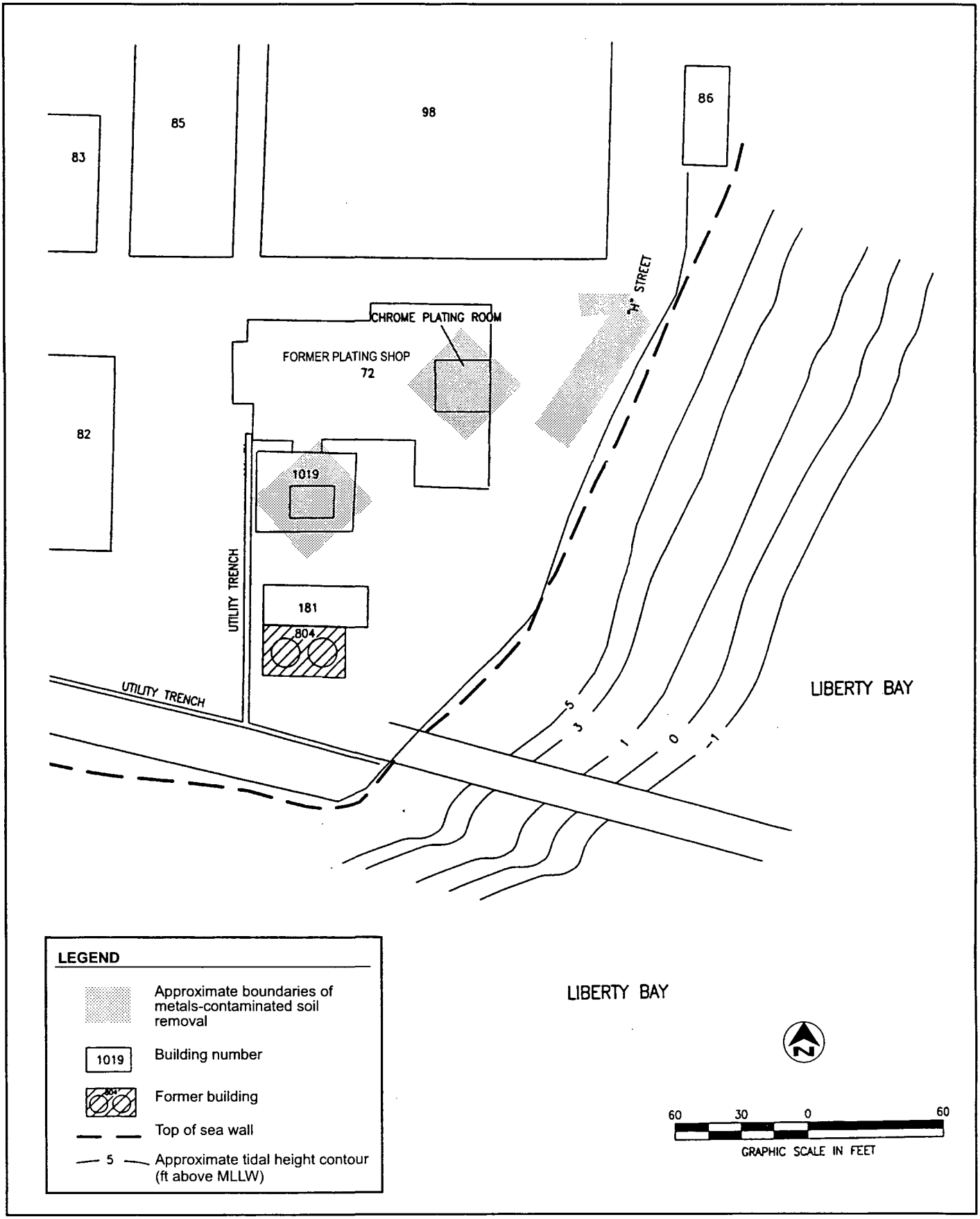
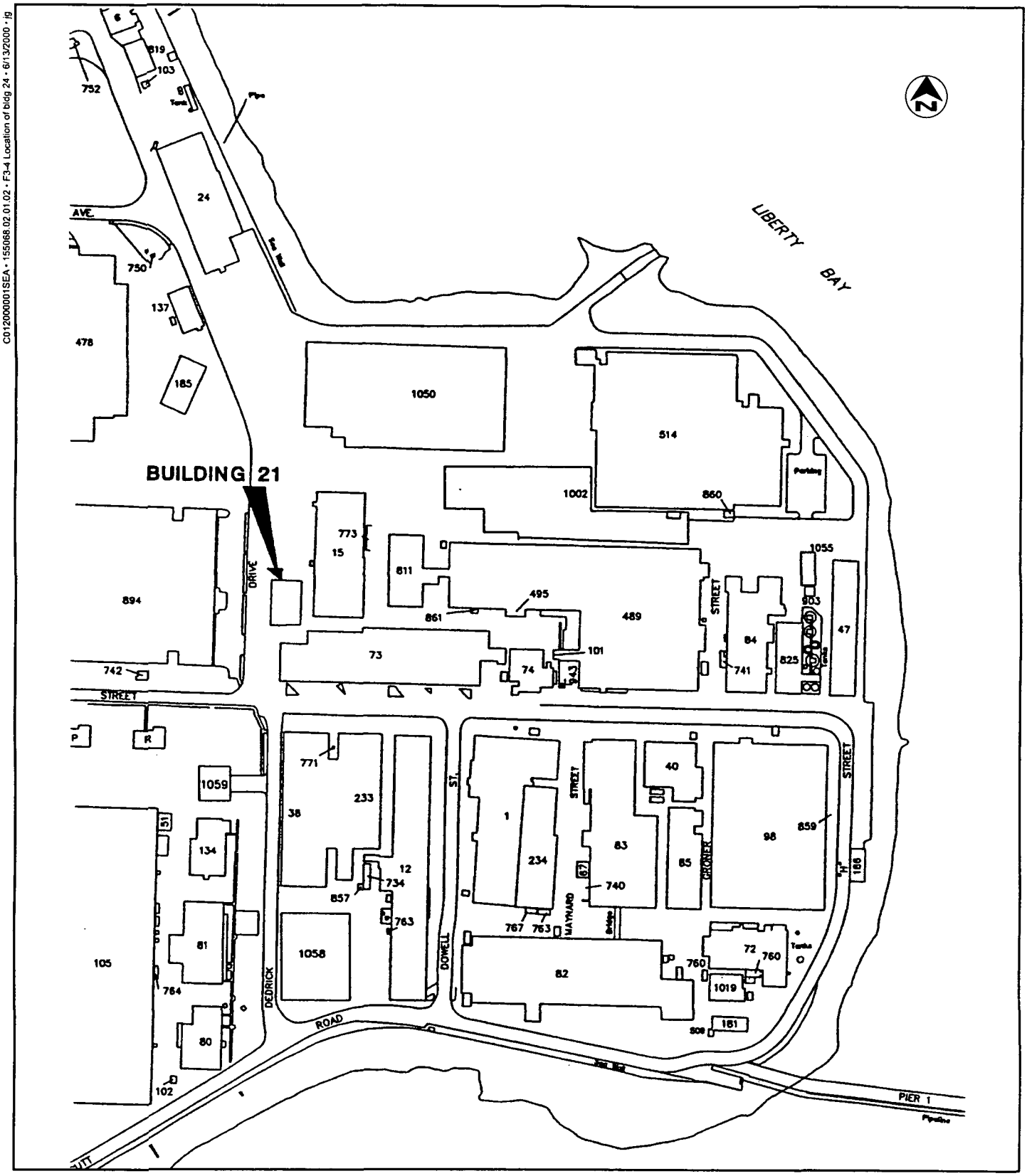


FIGURE 3-3

Area 8 Hot Spot Removal Boundaries

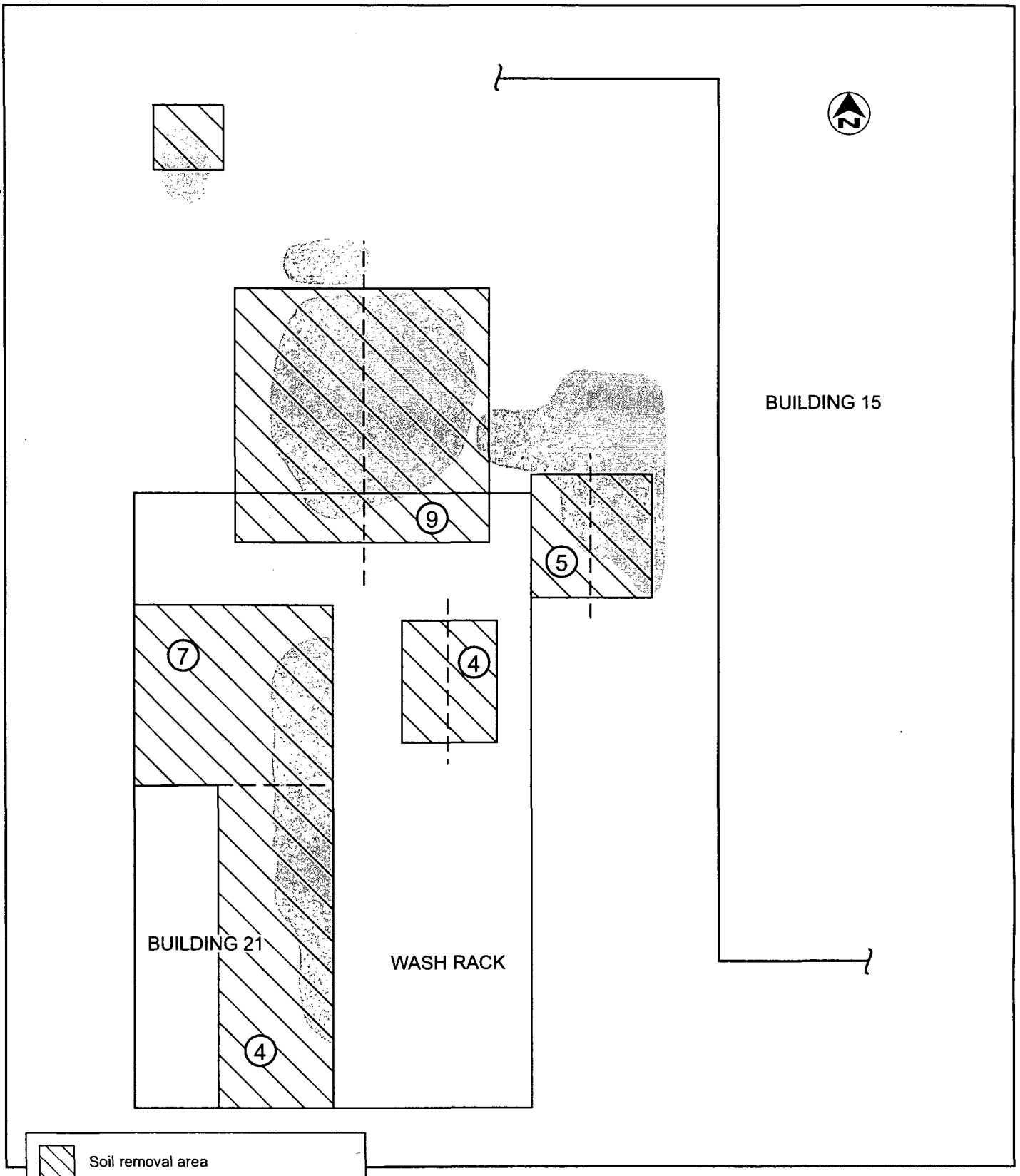
NUWC Keyport, Washington

C012000001SEA • 155068.02.01.02 • F3-4 Location of bldg 24 • 6/13/2000 • jg



Source: Adapted from Foster Wheeler (2000b)

FIGURE 3-4
Location of Building 21
NUWC Keyport, Washington



Source: Adapted from Foster Wheeler (2000b)

FIGURE 3-5
Site 23/Building 21
Soil Removal Boundaries
NUWC Keyport, Washington

Table 3-1
Summary of Analytical Results for Surface Water Sampling Stations at Area 1
Updated through October 1999

Station ID	Sampling Date	Analyte Concentration (µg/L)								
		1,1-DCA	1,2-DCA	1,1-DCE	cis-1,2-DCE	trans-1,2-DCE	PCE	1,1,1-TCA	TCE	Vinyl Chloride
MA12	03/14/95	5 U	0.5 U	0.56	180 J	1.6	0.5 U	0.5 U	26	56 J
	7/01/96	11	0.5 U	1	480 J	3.5	0.5 U	0.5 U	64 J	56 J
	06/11/99	15	3 U	2 J	710	8	3 U	3 U	130	150
	10/20/99	12	0.5 U	1.9	600	5.5	0.5 U	0.5 U	110	130
SP1-1	09/05/95	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.66 J
	12/05/95	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
	03/13/96	0.5 U	0.5 U	0.5 U	170 J	1.8	0.5 U	0.5 U	0.5 U	420 J
	07/02/96	0.5 U	0.5 U	0.5 U	7.4	0.76	0.5 U	0.5 U	0.5 U	31 J
	09/10/96	0.2 J	0.5 U	0.5 U	0.33 J	0.5 U	0.5 U	0.5 U	0.5 U	1.1
	06/11/99	3 U	3 U	3 U	4	3 U	3 U	3 U	3 U	32
	10/20/99	0.5 U	0.5 U	0.5 U	0.5	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Remediation Goal			**59**	**1.9**		**33,000**	**4.2**	**41,700**	**56**	**2.9**

Notes:
Blank cell denotes no remediation goal has been established.
µg/L - microgram per liter
1,1-DCA - 1,1-dichlorethane
1,2-DCA - 1,2-dichloroethane
1,1-DCE - 1,1-dichloroethene
cis 1,2-DCE - cis -1,2-dichloroethene
trans-1,2-DCE - trans-1,2-dichloroethene
PCE - tetrachloroethene
1,1,1-TCA - 1,1,1-trichloroethane
TCE - trichloroethene
J - estimated result
U - compound was not detected at the value shown

Table 3-2
Summary of Analytical Results for Groundwater Sampling Stations at Area 1
Updated through October 1999

Station ID	Sampling Date	Analyte Concentration (µg/L)								
		1,1-DCA	1,2-DCA	1,1-DCE	cis-1 2-DCE	trans-1,2-DCE	PCE	1,1,1-TCA	TCE	Vinyl Chloride
MW1-1	08/25/95	14	1U	5.1	590J	180J	1U	1U	1U	1,000J
	12/06/95	1	1U	1U	87J	7.7	1U	1U	1U	210J
	03/12/96	8.5	0.5U	2.6	450J	120J	0.5U	0.5U	0.62	710J
	06/26/96	15	0.5U	3.2	460J	220J	0.5U	0.5U	0.51U	1,200J
	6/11/99	19	3U	4	310	170	3U	3U	3U	960
	10/20/99	17	0.5 U	2.9	320	190	0.5 U	0.5 U	0.5 U	970
MW1-2	08/28/95	1U	1U	4.2	1,400J	23	1U	1U	36J	150J
	12/06/95	1U	1U	3.5	1,300J	22	1U	1U	35J	140J
	03/11/96	0.5U	0.5U	4.8	1,800J	30J	0.5U	0.5U	41	200J
	06/25/96	0.23J	0.5U	5.1J	1,500J	31J	0.5U	0.5U	43J	180J
	6/11/99	3U	3U	5	980	26	3U	3U	27	160
	10/20/99	0.5 U	0.5 U	3.4	1,000	21	0.5 U	0.5 U	23	110
MW1-3	03/08/96	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
	06/21/96	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
	09/11/96	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
	10/20/99	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.7	0.5 U
MW1-4	08/23/95	1U	1U	7.7	6,400J	80J	2.2	1U	11,000J	2,000J
	12/05/95	1U	1U	5.2	3,900J	500U	1.7	1U	8,600J	2,800J
	03/05/96	0.67J	0.5UJ	5.6J	3,500J	56J	0.96J	0.5UJ	6,300J	1,100J
	06/20/96	0.64	0.5U	13	5,900J	41	4	0.5U	22,00J	970J
	6/14/99	2J	3U	24	12,000	140	4	3U	2,600E	1,500
	10/21/99	0.8	0.5 U	10	5,300	70	0.7	0.5 U	3,600	1,100
MW1-5	08/23/95	5.8J	1U	1U	17	1.3	1U	1U	1.9	140
	12/05/95	110J	1U	1U	74J	16	1U	1U	7.3	4,300J
	03/06/96	34	0.5U	0.5U	60	7	0.5U	0.5U	3	1,100
	06/20/96	29J	0.5U	0.24J	93J	6.5	0.5U	0.5U	1.7	1,500J
	6/14/99	9	3U	3U	9	2J	3U	3U	2J	260
	10/21/99	9.6	0.5 U	0.5 U	0.5	0.5	0.5 U	0.5 U	0.5 U	18
MW1-16	08/31/95	12,000J	15J	680J	14,000J	520J	0.51J	5,600J	250J	12,000J
	06/20/96	30,000J	35J	180J	3,100J	180J	1.3J	430J	34J	2,200J
	6/14/99	15,000	17	48	6,800	160	1J	140	530	1,700
	10/21/99	6,500	9	5	28	26	1.2	23	9.2	28
MW1-20	08/30/95	1U	1U	1U	1U	1U	1U	1U	1U	1U
	12/08/95	1U	1U	1U	1U	1U	1U	1U	1U	1U
	03/11/96	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
	6/27/99	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U	0.5U
	10/21/99	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5U	0.5U	0.5U	0.5U
MW1-41	6/21/99	NA	NA	NA	NA	NA	NA	NA	NA	NA
	10/21/99	0.5 U	0.5 U	0.5 U	0.6	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Remediation Goals		**800**	**5**	**0.5**	**70**	**100**	**5**	**200**	**5**	**0.5**

Notes:

µg/L - microgram per liter
1,1-DCA- 1,1-dichlorethane
1,2-DCA - 1,2-dichloroethane
1,1-DCE - 1,1-dichloroethene
cis 1,2-DCE - cis -1,2-dichloroethene
trans-1,2-DCE - trans-1,2-dichloroethene
PCE - tetrachloroethene
1,1,1-TCA - 1,1,1-trichloroethane
TCE - trichloroethene
E - the value shown exceeds the instrument calibrating range
J - estimated result
U - compound was not detected at the value shown

Table 3-3. Summary and Breakdown of Products Detected in Groundwater at Area 2, Fall 1995 - Fall 1999

Analyte Detected	Date Collected	Units	MTCA Method B Cleanup Level Drinking Water Remediation Goal (a) (µg/L)	2MW-1		2MW-3		2MW-4		2MW-5		2MW-6	
				Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Trichlorethene	11/95	µg/L	5 (b)	40		1	J	1	U	11		1	U
	9/96	µg/L		28		NS		NS		2		1	U
	10/97	µg/L		27		NS		NS		2		1	U
	10/98	µg/L		28		NS		NS		2.1		0.2	U
	11/99	µg/L		17		NS		NS		0.4	J	0.5	U
cis-1,2-Dichloroethene	11/95	µg/L	70	1	U	19		1	U	7		10	
	9/96	µg/L		1	U	NS		NS		1	U	15	
	10/97	µg/L		1	U	NS		NS	U	1	U	11	
	10/98	µg/L		0.2	U	NS		NS		0.26		9.5	
	11/99	µg/L		0.5	U	NS		NS		0.5	U	12	
Vinyl chloride	11/95	µg/L	1 (c)	1	U	4		1	U	1	U	4	
	9/96	µg/L		1	U	NS		NS		1	U	5	
	10/97	µg/L		1	U	NS		NS		1	U	4	
	10/98	µg/L		0.2	U	NS		NS		0.2	U	2.7	
	11/99	µg/L		0.5	U	NS		NS		0.5	U	2.7	

(a) Protective of human health by ingestion pathway

(b) Value listed accounts for adjustment when the MCL or water quality standard is sufficiently protective to serve as the MTCA cleanup level for that individual chemical. Individual chemical cleanup levels may require downward adjustment for multiple chemical contaminants or multiple exposure pathways (MTCA Implementation Memo No.1 (Kraege 1993). Value does not account for adjustments due to background levels or practical laboratory quantitation limits. (PQLs)

(c) The MTCA Method B cleanup level for vinyl chloride is 0.023 µg/L. This cleanup level is below the PQL of standard EPA analytical methods for drinking water. In such cases, the MTCA cleanup standard was adjusted based on the PQL, as stipulated in WAC 173-340-700(6) (Robb 1993). The PQL for EPA Method 524.2 with a 25 ml purge is 1 µg/L.

U = Not detected J = Estimated NS = Not Sampled

Table 3-4. Comparison of Area 2 Rounds 1 to 5 Groundwater Sampling Results to the Remedial Investigation Results

Analyte	Remedial Investigation[1] Range of Detects		First Round[2] Range of Detects		Second Round[3] Range of Detects		Third Round[4] Range of Detects		Fourth Round[5] Range of Detects		Fifth Round[6] Range of Detects	
	Minimum (µg/L)	Maximum (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Minimum (µg/L)	Maximum (µg/L)
Volatile Organic Compounds (VOCs)												
Trichloroethene	24	36	1	40	2	28	2	27	2.1	28	0.3	17
Vinyl Chloride	3	4	4	4	5	5	4	4	2.7	2.7	2.7	2.7

[1] URS (1993), Remedial Investigation, Table 4-66.

[2] First round of monitoring at Area 2 conducted fall 1995.

[3] Second round of monitoring at Area 2 conducted fall 1996.

[4] Third round of monitoring at Area 2 conducted fall 1997.

[5] Fourth round of monitoring at Area 2 conducted fall 1998.

[6] Fifth round of monitoring at Area 2 conducted fall 1999.

Table 3-5. Summary of Selected VOCs Detected in Groundwater at Area 8, Fall 1995 - Fall 1999

Analyte Detected	Date Collected	MTCA Method B Drinking Water (a) µg/L	MTCA Method B Surface Water µg/L	MW8-6 Result µg/L	MW8-8 Result µg/L	MW8-9 Result µg/L	MW8-11 Result µg/L	MW8-12 Result µg/L	MW8-14 Result µg/L	MW8-16 Result µg/L
Trichloroethene	11/95	5 (b)	81 (b,c)	ns	190 D	1600 D	84 D	85 D	1 U	58 D
	6/96			57 D	110 D	800 D	84 D	63 D	1 U	72 D
	9/96			ns	190 D	1000 D	80 D	120 D	1 U	69 D
	5/97			ns	68 D	1600 D	63 D	120 D	1 U	57 D
	10/97			ns	78 D	720 D	62 D	44 D	1 U	47 D
	5/98			ns	63 D	370 D	61 D	46 D	1 U	61 D
	10/98			ns	76 D	610 D	62 D	46 D	1 U	47 D
	5/99			ns	58 D	84 D	27 D	25	1 U	40
	11/99			ns	150 H	500	54 H	50 H	0.5 U	63
Tetrachloroethene	11/95	5 (b)	8.9 (b,c)	ns	49 D	50 U	1 U	13	1 U	0.6 J
	6/96			16	34	1 U	1 U	5	1 U	0.8 J
	9/96			ns	58 D	0.4 J	1 U	23	1 U	0.8 J
	5/97			ns	15	0.3 J	1 U	12	1 U	0.8 J
	10/97			ns	19	1 U	1 U	7	1 U	0.6 J
	5/98			ns	12	1 U	1 U	10	1 U	0.8 J
	10/98			ns	30	1 U	1 U	15	1 U	1 U
	5/99			ns	5 U	1 U	2 U	4 U	1 U	1 U
	11/99			ns	2	0.6	0.5 U	9.7	0.5 U	0.8
1,1-Dichloroethene	11/95	7 (b)	3.2 (b,c)	ns	1	50 U	44 D	10	1 U	1 U
	6/96			1 U	0.9 J	1 U	47 D	14	1 U	1 U
	9/96			ns	1	1 U	27 D	20	1 U	1 U
	5/97			ns	1 U	1 U	42 D	6	1 U	1 U
	10/97			ns	0.6 U	1 U	30 D	4	1 U	1 U
	5/98			ns	1 U	1 U	33	2	1 U	1 U
	10/98			ns	1 U	1 U	35 D	1 U	1 U	1 U
	5/99			ns	5 U	1 U	8 D	1 U	1 U	1 U
	11/99			ns	1	0.5 U	12	0.9	0.5 U	0.5 U
cis-1,2-Dichloroethene	11/95	70	xxx	ns	2	27 J	1 U	1	1 U	2
	6/96			2	1	28	1 U	1 U	1 U	2
	9/96			ns	2	28	0.3 J	2	1 U	3
	5/97			ns	1	34 D	1 U	1	1 U	2
	10/97			ns	1 U	1 U	2	1 U	1 U	1 U
	5/98			ns	0.9 J	12	1 U	2	1 U	2
	10/98			ns	1 U	34 D	1 U	1 U	1 U	3
	5/99			ns	5 U	6	2 U	1 U	1 U	6
	11/99			ns	3.2	30	0.5 U	2.1	3.2	5.3
1,1,1-Trichloroethane	11/95	200	42000	ns	23	50 U	520 D	140 D	1 U	2
	6/96			7	11	2	460 D	180 D	1 U	2
	9/96			ns	19	2	420 D	250 D	1 U	2
	5/97			ns	3	2	500 D	67 D	1 U	2
	10/97			ns	9	1	300 D	41 D	1 U	2
	5/98			ns	3	0.7 J	200 D	20	1 U	1
	10/98			ns	9	3	220 D	22	1 U	1 U
	5/99			ns	5 U	1 U	45 D	8	1 U	2
	11/99			ns	10	1.4	64 H	14	0.5 U	1.7

(a) Protection of human health by ingestion pathway.

(b) Value listed accounts for adjustment when the MCL or water quality standard is sufficiently protective to serve as the MTCA cleanup level for that individual chemical. Individual cleanup levels may require downward adjustment for multiple chemical contaminants or multiple exposure pathways (MTCA Implementation Memo No. 1 (Kraege 1993). Value does not account for adjustments due to background levels or practical laboratory quantitation limits.

(c) Protective of human health by fish ingestion pathway

xxx = No value given.

ns = Not sampled.

U = Not detected.

J = Estimated.

D = Diluted.

H = Analytical result is from an analysis reported past the holding time.

Table 3-6. Summary of Inorganics Detected in Groundwater and Seeps at Area 8 Exceeding One-half of the Method B Cleanup Levels, Fall 1995 - Fall 1999

Analyte Detected	Date Collected	MTCA Method B Cleanup Level		MW8-6	MW8-8	MW8-9	MW8-11	MW8-12	MW8-14	MW8-16	SEEP A	SEEP B	MW8-7	MW8-15	MW8-17	MW8-18	MW8-19	MW8-20
		Drinking Water (µg/L)	Surface Water (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)
Arsenic, total	11/95	0.05	0.14 [b,c,f]	ns	(-)	3.0 NW	2.0 W+	5.1 N	5.1 W+	2.3 +	ns	ns	3.3 +	(-)	3.0 N	1.8 N	3.3 NW	(-)
Arsenic, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	1.0 UN	NA	1.2 N	1.9 N	NA
Arsenic, dissolved (ICP)	6/96			1.1 B	1.4 B	2.6 B	1.0 U	3.6 B	3.3 B	2.8 B	1.3 B	4.6 B	ns	ns	ns	ns	ns	ns
Arsenic, total (ICP)	6/96			NA	NA	NA	NA	NA	NA	NA	ns	3.0 B	ns	ns	ns	ns	ns	ns
Arsenic dissolved	9/96			ns	(-)	3.4 BW	2.4 BW	1.9 B	3.1 BW	2.9 B	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	5/97			ns	2.0 UN	3.2 NW	2.1 NW	2.0 UN	2.8 NW	2.3 N	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	10/97			ns	0.50 UN	1.4 BNW	0.66 BNW	1.8 BN	1.0 BNW	1.4 BN	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	5/98			ns	0.5 U	1.1 BW	0.50 UW	2.4 BW	0.86 BW	1.2 B	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	10/98			ns	1.8 U	5.4 B	2.1 B	1.8 U	10.8	1.8 U	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	5/99			ns	1.7 U	2.0 B	2.6 B	1.7 U	2.2 B	1.7 U	ns	ns	ns	ns	ns	ns	ns	ns
Arsenic dissolved	11/99			ns	5 U	5 U	5 U	NA	5 U	5 U	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, total	11/95	5	8 [d]	ns	(-)	(-)	251	28.6	22.4	(-)	ns	ns	(-)	(-)	(-)	(-)	(-)	(-)
Cadmium, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	(-)	NA	(-)	(-)	NA
Cadmium, total	6/96			NA	NA	NA	NA	NA	NA	NA	46.7	(-)	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	6/96			(-)	(-)	(-)	444	46.1	10.9	(-)	33.9	(-)	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	9/96			ns	(-)	3.5 B	262	53.8	19.9	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	5/97			ns	(-)	(-)	210	565	9.8	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	10/97			ns	(-)	(-)	278	154	3.2	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium dissolved	5/98			ns	(-)	(-)	320	7.3	12.6	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, dissoved	10/98			ns	(-)	(-)	126 E	6.5 E	16.9 E	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	5/99			ns	(-)	(-)	33.5 N	45.7 N	10.5 N	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cadmium, dissolved	11/99			ns	2.5	14	205	(-)	13	4U	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, total	9/96			ns	330	(-)	626	1740	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved (h)	5/97	50 [b]	xx	ns	319	(-)	441	1280	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	10/97			ns	372	(-)	377	961	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	5/98			ns	344	(-)	303	728	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	10/98			ns	322	(-)	459	1090	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	5/99			ns	184 N	(-)	198	815 N	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	11/99				154	8	201	(-)	7	5U	ns	ns	ns	ns	ns	ns	ns	ns
Chromium VI, total	11/95	80	50 [d]	ns	390	(-)	950	1500	90	(-)	ns	ns	(-)	(-)	(-)	(-)	(-)	(-)
Chromium VI (h), total	6/96			(-)	380	380	800	380	(-)	(-)	240	(-)	ns	ns	ns	ns	ns	ns
Chromium VI, total	9/96			ns	320	(-)	720	1800	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Chromium, dissolved	5/97			ns	350	(-)	610	1400	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Copper, total	11/95	590 [e]	2.5 [d]	ns	4.8 +	3.6 W+	13.4 S	329 S+	152 S	(-)	ns	ns	(-)	2.5 +	26.7 S+	3.8 +	22.9 S+	7.9 +
Copper, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	(-)	NA	(-)	1.3 +	NA
Copper, total	6/96			NA	NA	NA	NA	NA	NA	NA	7.8 B	24.5 B	ns	ns	ns	ns	ns	ns
Copper, dissolved	6/96			(-)	(-)	(-)	18.9 B	(-)	6.7 B	(-)	5.1 B	8.5 B	ns	ns	ns	ns	ns	ns
Copper, dissolved	9/96			ns	(-)	(-)	14.3 B	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	nsns	ns
Copper, dissolved	5/97			ns	2.0 U	2.0 U	12.4	64.4	2.0 U	2.0 U	ns	ns	ns	ns	ns	ns	ns	ns
Copper, dissolved	10/97			ns	2.3 B	(-)	11.7 B	150	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Copper, dissolved	5/98			ns	(-)	(-)	12.5 B	5.2 B	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Copper, dissolved	10/98			ns	(-)	(-)	9.0 B	4.0 B	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Copper, dissolved	5/99			ns	(-)	(-)	5.3 B	19.9 B	13.2	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Copper, dissolved	11/99			ns	10 U	10 U	10 U	NA	10 U	10 U	ns	ns	ns	ns	ns	ns	ns	ns
Lead, total	11/95	15 [b,e]	5.8 [b,d]	ns	(-)	(-)	(-)	11.7	203 N	(-)	ns	ns	(-)	(-)	(-)	(-)	3.2	(-)
Lead, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	(-)	NA	(-)	ns	NA
Lead, dissolved	5/97			ns	(-)	(-)	(-)	20 UN	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Lead, dissolved	10/97			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Lead, dissolved	5/98			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Lead, dissolved	10/98			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Lead, dissolved	5/99			ns	(-)	(-)	(-)	3.2 N	(-)	3.4 N	ns	ns	ns	ns	ns	ns	ns	ns
Lead, dissolved	11/99			ns	2 U	2U	2U	NA	2U	2 U	ns	ns	ns	ns	ns	ns	ns	ns

Table 3-6. Summary of Inorganics Detected in Groundwater and Seeps at Area 8 Exceeding One-half of the Method B Cleanup Levels, Fall 1995 - Fall 1999

Analyte Detected	Date Collected	MTCA Method B Cleanup Level		MW8-6	MW8-8	MW8-9	MW8-11	MW8-12	MW8-14	MW8-16	SEEP A	SEEP B	MW8-7	MW8-15	MW8-17	MW8-18	MW8-19	MW8-20
		Drinking Water (µg/L)	Surface Water (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)
Mercury, total	11/95	2	0.025 [b,d]	ns	(-)	(-)	0.22	0.19	0.52	0.16	ns	ns	0.11	(-)	0.11	(-)	(-)	(-)
Mercury, dissolved	5/97			ns	.20 U	.20 UN	.20 UN	.20 UN	.20 UN	.20 UN	ns	ns	ns	ns	ns	ns	ns	ns
Mercury, dissolved	10/97			ns	0.10 U	0.35	0.32	0.10 U	0.48	0.10 U	ns	ns	ns	ns	ns	ns	ns	ns
Mercury, dissolved	5/98			ns	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	0.10 U	ns	ns	ns	ns	ns	ns	ns	ns
Mercury, dissolved	10/98			ns	0.10 U	0.13 B	0.17 B	0.15 B	0.15 B	0.10 U	ns	ns	ns	ns	ns	ns	ns	ns
Mercury, dissolved	5/99			ns	0.10 U	0.10 U	0.10 B	0.10 U	0.10 U	0.11 B	ns	ns	ns	ns	ns	ns	ns	ns
Mercury, dissolved	11/99			ns	0.2 U	0.2 U	0.2 U	NA	0.2U	0.2 U	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, total	11/95	100	7.9 [d]	ns	12.8 +	(-)	51.3	34.6 +	100	(-)	ns	ns	(-)	(-)	35.2 +	16.0 +	25.7 +	18.6 +
Nickel, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	9.3 +	NA	9.0 +	9.0 U +	NA
Nickel, dissolved	6/96			(-)	(-)	(-)	39.5 B	17.9 B	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns
Nickel, dissolved	9/96			ns	(-)	(-)	42.3	49.3	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	5/97			ns	5.0 U	5.0 U	30.5	673	5.0 U	5.0 U	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	10/97			ns	11.0 U	11.0 U	40.0	423	11.0 U	11.0 U	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	5/98			ns	4.0 U	7.0 B	36.9 B	7.5 B	4.8 B	5.7 B	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	10/98			ns	(-)	38.2 B	16.2 B	8.9 B	4 B	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	5/99			ns	3.5 BN	16.3 BN	4.6 BN	70.0 N	(-)	4,1 BN	ns	ns	ns	ns	ns	ns	ns	ns
Nickel, dissolved	11/99			ns	20 U	20 U	20 U	NA	20 U	20 U	ns	ns	ns	ns	ns	ns	ns	ns
Silver, total	11/95	48	1.2 [d]	ns	(-)	(-)	4.2	(-)	(-)	(-)	ns	ns	(-)	(-)	(-)	(-)	(-)	(-)
Silver, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	3.0 UNW	NA	3.0 UNW	3.0 UNW	NA
Silver, dissolved	9/96			ns	(-)	(-)	(-)	(-)	8.6 B	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	5/97			ns	4.0 U	4.0 U	7.0 N	40 UN	7.3 N	4.0 UN	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	10/97			ns	1.8 B	1.0 U	4.4 B	1.8 B	2.0 B	1.0 U	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	5/98			ns	1.0 UN	1.0 UN	5.2 BN	1.0 BN	1.2 BN	1.0 UN	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	10/98			ns	1.0 UN	2.0 B	2.2 B	1.2 B	1.0 U	1.0 U	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	5/99			ns	2.2 U	2.7 B	2.2 U	2.2 U	2.2 U	2.2 U	ns	ns	ns	ns	ns	ns	ns	ns
Silver, dissolved	11/99			ns	10 U	10	10	NA	10 U	10 U	ns	ns	ns	ns	ns	ns	ns	ns
Thallium, total	11/95	1.1	1.6	ns	(-)	(-)	(-)	(-)	(-)	(-)								
Thallium, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	2.4 +	(-)	(-)	(-)	(-)	(-)
Thallium, dissolved	6/96			(-)	1.2 BN	(-)	(-)	(-)	(-)	1.1 BNW	ns	ns	NA	2.0 U	NA	2.0 U	2.0 U	NA
Thallium, dissolved	5/97			ns	1.0 UN	134 N	10.0 UW	1.0 UNW	10.0 UN	1.0 UNW	(-)	(-)	ns	ns	ns	ns	ns	ns
Thallium, dissolved	10/97			ns	1.8 UN	1.8 UNW	9.0 UNW	1.8 UNW	1.8 UBN	1.8 UN	ns	ns	ns	ns	ns	ns	ns	ns
Thallium, dissolved	5/98			ns	1.2 U	6.0 U	6.0 U	1.2 U	6.0 U	1.2 U	ns	ns	ns	ns	ns	ns	ns	ns
Thallium, dissolved	10/98			ns	1.2 U	6.0 UW	1.2 UW	1.2 U	6.0 UW	1.2 U	ns	ns	ns	ns	ns	ns	ns	ns
Thallium, dissolved	5/99			ns	1.0 UN	10.0 UNW	10.0 UNW	1.0 UNW	10.0 UNW	1.0 UNW	ns	ns	ns	ns	ns	ns	ns	ns
Thallium, dissolved	11/99			ns	5 U	5 U	5 U	NA	5 U	5 U	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, total	11/95	4,800	77 [d]	ns	(-)	(-)	207	(-)	241	(-)	ns	ns	(-)	(-)	(-)	(-)	(-)	(-)
Zinc, dissolved	11/95			NA	NA	NA	NA	NA	NA	NA	ns	ns	NA	35.6	NA	(-)	(-)	NA
Zinc, dissolved	6/96			54.8	(-)	(-)	248	29.7	29.9	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns
Zinc, dissolved	9/96			ns	(-)	(-)	166	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	5/97			ns	(-)	(-)	161	727	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	10/97			ns	(-)	(-)	178	325	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	5/98			ns	(-)	(-)	193	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	10/98			ns	(-)	(-)	50.9	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	5/99			ns	(-)	(-)	(-)	48.9	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Zinc, dissolved	11/99			ns	10 U	10 U	89	NA	10 U	10 U	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, total	11/95	200 [g]	1 [d]	ns	(-)	(-)	24	47	(-)	(-)	ns	ns	(-)	(-)	(-)	(-)	(-)	(-)
Cyanide, total	6/96			(-)	(-)	(-)	20	31	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns
Cyanide, total	5/97			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, total	10/97			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, total	5/98			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, total	10/98			ns	10 U	10 U	11	58	10 U	10 U	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, total	5/99			ns	(-)	(-)	(-)	(-)	(-)	(-)	ns	ns	ns	ns	ns	ns	ns	ns
Cyanide, dissolved	11/99			ns	0.01 U	0.01 U	0.03	NA	0.01 U	0.01 U	ns	ns	ns	ns	ns	ns	ns	ns

(a) Protection of human health by ingestior

(b) Value listed accounts for adjustment when the MCL or water quality standard is sufficiently protective to serve as the MTCA cleanup level for the invidivual chemical. Individual cleanup levels may require downward adjustment for multiple exposure pathways (MTCA Implementation Memo No. 1 (Kraege 1993). Value does not account for adjustments due to background levels or practical laboratory quantitation limits.

Table 3-6. Summary of Inorganics Detected in Groundwater and Seeps at Area 8 Exceeding One-half of the Method B Cleanup Levels, Fall 1995 - Fall 1999

Analyte Detected	Date Collected	MTCA Method B Cleanup Level		MW8-6	MW8-8	MW8-9	MW8-11	MW8-12	MW8-14	MW8-16	SEEP A	SEEP B	MW8-7	MW8-15	MW8-17	MW8-18	MW8-19	MW8-20
		Drinking Water (µg/L)	Surface Water (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)	Result (µg/L)

(c) Protection of human health by fish ingestion.
(d) Protection of marine species. Value listed is the lower of the chronic or acute standard for marine water
(e) The standards for copper and lead are "treatment techniques." Copper and lead have action levels rather than MCLs. When applied to a purveyor of a public water supply, if the concentration at the tap exceeds the action level, this requires implementation of specified treatment techniques (40 CFR 261 Subpart I).
(f) Value listed is the lower of the cancer or noncancer value
(g) If the federal MCL is more stringent than MTCA Method B, then the federal MCL becomes the MTCA Method B cleanup leve
(h) Results for chromium are less than the results reported for Chromium VI due to variation in analytical methods. Variance in results for these analytes is common. In addition, the unspeciated chromium samples were filtered and the chromium VI samples were not.
(-) = Undetected above 1/2 the MTCA Method B cleanup levels
ns = not sampled.
NA - not analyzed
+ = Duplicate analysis is not within control limits
B = Between instrument detection limit and contract required detection limit.
E = Reported value is estimated because of presence of interference.
N = Spiked sample is outside of control limits.
S = Determined by method of standard additions
W = Post-digestion spoke for furnace atomic absorption spectrophotometric analysis is out of control limits (85 - 115%) and sample is less than 50% of spike absorbance.
U = Not detected at or above method detection limit.
xx = No value given.

Table 3-7. Comparison of Area 8 Groundwater Sampling Results (Fall 1995 - Fall 1999) to the Remedial Investigaton Results

Analyte	Remedial Investigation[1] Range of Detects		Fall 1995 Range of Detects		Spring 1996 Range of Detects		Fall 1996 Range of Detects		Spring 1997 Range of Detects		Fall 1997 Range of Detects		Spring 1998 Range of Detects		Fall 1998 Range of Detects		Spring 1999 Range of Detects		Fall 1999 Range of Detects	
	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)	Min. (µg/L)	Max. (µg/L)
Volatile Organic Compounds (VOCs)																				
1,1,1-Trichloroethane	2	2500	0.7	520	1	460	2	470	2	500	u	300	u	200	u	220	u	45	u	64
1,1-Dichloroethane	1	100	1	1	u	u	0.4	2	2	2	u	0.4	u	u	u	u	u	u	u	0.7
1,1-Dichloroethane	1	94	1	44	u	u	1	31	6	42	u	30	u	33	u	35	u	8	u	12
1,2-Dichloroethane	2	5	2	2	0.9	47	2	2	2	2	u	2	u	1	u	3	u	0.7	u	0.8
Chloroform	1	10.8	0.5	19	0.5	1	0.4	1	0.4	1	u	1	u	1	u	u	u	2	u	1.8
Tetrachloroethene	2	130	0.6	49	0.8	34	0.4	58	0.3	15	u	19	u	12	u	30	u	4	u	9.7
Toluene	7	28	32	32	u	u	u	u	u	u	u	0.1	u	u	u	u	u	0.9	u	u
Trichloroethene	1	3100	14	1600	57	800	69	1000	57	1600	u	720	u	370	u	610	u	84	u	500
Inorganic Compounds																				
Arsenic	23	68	1.2	5.1	1.1	3.6	1.9	3.4	2.1	3.2	0.5	1.8	0.5	2.4	u	10.8	u	26	u	u
Barium	153	284	23.7	88.5	99.2	99.2	35.9	88.5	8.1	62.9	u	91.4	1.5	104	u	192	93	107	26	153
Cadmium	3.4	1780	22.4	299	10.9	444	3.5	264	9.5	565	u	278	u	320	0.2	126	0.26	45.7	u	205
Chromium	4	5390	8.5	1790	384	852	13.4	1740	8.5	1280	5.6	1030	u	728	0.99	1090	0.70	815	u	201
Hexavalent Chromium	1	5000	10	1500	380	800	10	1800	10	1400	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Copper	3.5	78.5	1.2	152	6.7	18.9	13.4	14.3	12.4	64.4	u	155	u	12.5	u	9	u	19.9	u	u
Lead (dissolved)	1	17.8	1.2	203	1.3	1.3	u	u	1.2	1.2	u	u	u	2	u	u	u	3.4	u	u
Mercury	0.24	0.24	0.11	0.52	u	u	u	u	u	u	u	0.48	u	u	u	0.17	u	0.11	u	u
Nickel	5.8	3550	12.8	100	17.9	39.5	41.0	49.3	30.5	673	u	423	u	36.9	u	38.2	3.5	70.0	u	u
Thallium	1.1	40	2.4	2.4	1.1	1.2	u	u	134	134	u	u	u	u	u	u	u	u	u	u
Zinc	102	394	7	241	14.9	24.8	17.6	168	9.2	727	6.8	344	u	193	u	50.9	u	48.9	u	89
Cyanide	18	xxx	23	47	20	31	0.016	0.034	0.038	0.038	u	0.039	u	0.15	u	58	u	u	u	0.03

[1]URS (1993), Remedial Investigation, Table 4-101 and Table 4-102

xxx = No value given.

u = Not detected at or above method detection limit.

ns = Not sampled.

Table 3-8. Concentrations of Detected Chemicals in Sediments from Area 8, NUWC Keyport, from May 1996 Sampling Events

Sampling Stations		Station 1	Station 2		Station 3		Station 4	Station 5	Station 6		Station 7	Station 8	Station 9	Station 10		Station 11	Station 12
Chemical Class	Sample No. / Chemical	2	8	25	13	17	21	28	23	37	40	46	51	60	75	66	71
Base-Neutral Extractables (µg/kg)																	
	4-Methylphenol	220 J	890	1100			110 J				1500	1200		140 J	60 J	97 J	
	Benzyl butyl phthalate											330 J					
	Phenol	3000 J	1900	1500	110 J		240 J	530				5200	240 J	260 J	280 J	450	
PAH (µg/kg)																	
	Acenaphthene	170			40 J			73	25 J			60	67		39 J		
	Anthracene	12		4.2 J	7.7			3.1 J				7.3	4.7 J		5.7		
	Benzo[a]pyrene	58	5.4	14	41	8.8	7.1	17	19	3.2	1.4 J	19	10		10		2.2 J
	Benzo[b]fluoranthene	88	8.8	18	56	14	10	24	26	5	2.2 J	23	1.5	1.6 J	12		4
	Benzo[g,h,i]perylene	38	6.2	10	26	7.3	4.7	14	11	2.5		11	7.6		7.3		1.8 J
	Benzo[k]fluoranthene	36	3.3	6.5	18	5	3.9	8.5	8.5	1.8 J		9	5.9		5.1		
	Benz[a]anthracene	55	3.1	7.5	11	4.5	7.2	11	9.6	1.7 J		13	9.4		7.4		1.4 J
	Chrysene	75	7.9	17	30	12	12	27	26	3.9 J		26	29		12		
	Dibenz[a,h]anthracene	4.2			3.2			1.5 J				1.3 J					
	Fluoranthene	110	13		19	19	9.1	44	11	5.3 J	11	49	59		38		
	Indeno[1,2,3-cd]pyrene	24	3.7	6.4	17	4.6	2.7	8.2	7.2	1.7 J		7.1	4.4		5.1		
	Phenanthrene	14		4.5 J	12	6.7		12			13	22	22				
	Pyrene	110	9.9		20	15	9.5	32	12	6.3 J	9.2 J	41	41		27		
Other (mg/kg)																	
	Total Organic Carbon	16,600	6,180		5,220		11,300	6,020	7,080		34,000	39,100	17,700	7,830		3,180	4,350
Volatile Organic Chemicals																	
	Acetone	110 J*										71					
Metals (µg/kg)																	
	Cadmium	0.6	1.6	2.0	8.1	7.5	4.8	2.0	3.4	2.1		0.2 J	0.5				
	Chromium	14.1 J	25.7 J	34.9 J	166.0 J	152.0 J	46.4 J	65.4 J	141.0 J	194.0 J	54.0 J	48.0 J	83.7 J	16.4 J	13.9 J	15.7 J	29.2 J
	Copper	6.4 J	16.5	7.7 J	12.5	9.7	10.6	8.7	8.3	10.4	10.5	7.4	11.3	7.1 J	6.4 J	6.4 J	10.6
	Gold	1.4	2.1	1.6 J	2.3	2.0	2.5	1.2 J	1.9	1.9	1.9 J	1.1 J	1.3 J	1.6 J	1.6 J	1.4 J	2.0
	Lead	6.6 J	3.0 J	3.1 J	5.5 J	5.0 J	6.5 J	5.5 J	10.5 J	6.1 J	7.8 J	4.4 J	7.4 J	2.7 J	2.2 J	1.9	3.5 J
	Mercury		.6 J	1.9 J	.1 J	0.2 J											
	Nickel	10.2	15.8	12.3	28.0 J	18	29.5	19.8	21.7	21.7	24.8	14.0	20.7	16.8	15.6	17.9 J	29.0
	Silver	.3 J	.8 J	.4 J	.8 J	0.6 J	0.6 J	0.3 J	0.4 J	0.3 J		0.2 J	0.3 J				
	Tin	.8 J	1.6 J	1.5 J	2.1 J	2.0 J	1.3 J	0.9 J	1.7 J	1.6 J	1.5 J	0.9 J	2.2 J	2.7 J	0.5 J	1.6 J	1.3 J
	Zinc	29.5 J	39.1 J	32.5 J	42.7 J	37.7 J	47.0 J	35.1 J	33.4 J	41.8 J	46.8 J	27.3 J	38.3 J	25.0 J	22.2 J	22.8 J	38.7 J

J = Estimated value, positively identified. (Most "J" qualified data are detected values below the detection limit.)
* Data validation report suggests that acetone is likely a laboratory or field contaminant.
Undetected chemicals qualified as "U" or "UJ," or rejected chemicals qualified as "R" are not reported.

Table 3-9. **Concentrations of Detected Chemicals in Clam Tissues from Area 8, NUWC Keyport, from May 1996 Sampling Events**

Station Location	Station 1		Station 2	Station 3		Station 4	Station 5	Station 6	Station 7	Station 8	Station 9		Station 10	Station 11	Station 12	
Chemical Class / Sample No. / Chemical	6	7	12	19	20	27	32	39	44	50	54	57	64	70	65	79
Base-Neutral Extractables																
Benzoic Acid	2600	1400	2000	1900	2400	1600	2000 J		1900 J	1800 J	2700 J	2700 J		1300 J	1600 J	1200 J
Phenol		240														
Metals																
Cadmium	1.10	1.50	5.40	5.65	5.75	2.20	1.01	1.5	0.25	0.22	0.22	0.21	0.37	0.22	0.20	0.21
Chromium	2.84	1.99	1.86	5.77	8.78	2.41	2.75	2.57	0.39	2.20	2.40	3.24	0.20	0.95	3.39	2.33
Copper	1.82	1.13	1.71	1.35	1.73	1.5	1.38	1.11	1.66	1.53	1.64	1.13	0.90	1.11	1.65	1.28
Hexavalent Chrome				2.20 J	2.20 J		1.70 J		6.50 J	4.00 J	5.90 J				0.94 J	3.60 J
Lead	0.21	0.10 J			0.12 J		0.14 J			0.21			0.16 J		0.19	0.14 J
Mercury	0.03	0.03	0.18	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	
Nickel	1.20	0.50	0.50	0.50	0.60	0.60	1.30	0.40	0.40	1.30	1.60	1.90	0.50	0.90	2.30	1.80
Silver	2.20	0.71	0.73	0.23	0.31	0.81	0.28	0.11	0.43	0.49	0.37	0.23	0.04	0.15	0.09	0.09
Zinc	14.10	14.10	16.50	17.50	17.00	13.60	13.20	13.70	15.00	11.10	14.00	10.90	16.10	15.40	15.80	15.10
PAH																
Fluoranthene					12 J	10	11		20	12	21 J	12			11 J	
Phenanthrene																
Pyrene						15 J	13 J		18 J						14 J	

J = Estimated value, positively identified. (Most "J" qualified data are detected values below the detection limit.)
* Data validation report suggests that acetone is likely a laboratory or field contaminant.
Undetected chemicals qualified as "U" or "UJ," or rejected chemicals qualified as "R" are not reported.

Table 3-10. Statistical Summary of Chemical Concentrations in Sediments (May 1996) from Area 8, NUWC Keyport, and Reference Area

Chemical Class	Chemical	Site Sediments						Reference Sediments					
		N	Minimum	Mean	Maximum	SD	UCL95	N	Minimum	Mean	Maximum	SD	UCL95
Volatile Organic Chemicals	Acetone	9	6.000	25.250	110.000	38.259	48.965	3	5.750	5.917	6.000	0.144	6.160
Base-Neutral Extractables	4-Methylphenol	9	110.000	538.889	1500.000	535.909	871.072	3	97.000	132.333	200.000	58.620	231.159
Base-Neutral Extractables	Benzyl butyl phthalate	9	195.000	229.444	330.000	40.113	254.308	3	192.500	195.833	200.000	3.819	202.271
Base-Neutral Extractables	Phenol	9	155.000	1276.667	5200.000	1759.693	2367.411	3	200.000	306.667	450.000	128.970	524.092
PAH	Acenaphthene	9	24.250	56.528	170.000	46.693	85.470	3	24.000	26.667	31.500	4.193	33.736
PAH	Anthracene	9	2.950	5.125	12.000	2.922	6.936	3	3.000	3.467	4.350	0.765	4.757
PAH	Benzo[a]pyrene	9	1.400	17.578	58.000	16.669	27.910	3	1.200	3.000	5.600	2.307	6.888
PAH	Benzo[b]fluoranthene	9	2.200	25.122	88.000	25.356	40.839	3	1.200	4.000	6.800	2.800	8.720
PAH	Benzo[g,h,I]perylene	9	1.400	12.022	38.000	10.784	18.707	3	1.200	2.417	4.250	1.616	5.141
PAH	Benzo[k]fluoranthene	9	1.400	9.583	36.000	10.353	16.001	3	1.200	1.850	3.150	1.126	3.748
PAH	Benzo[a]anthracene	9	1.400	12.856	55.000	16.163	22.874	3	1.200	2.300	4.300	1.735	5.225
PAH	Chrysene	9	3.500	24.544	75.000	20.691	37.370	3	3.000	4.517	7.500	2.584	8.873
PAH	Dibenz[a,h]anthracene	9	1.200	1.764	4.200	0.959	2.358	3	1.150	1.183	1.200	0.029	1.232
PAH	Fluoranthene	9	8.150	35.347	110.000	34.248	56.576	3	4.150	9.833	21.100	9.757	26.283
PAH	Indeno[1,2,3-cd]pyrene	9	1.400	7.567	24.000	6.791	11.776	3	1.200	1.850	3.150	1.126	3.748
PAH	Phenanthrene	9	2.950	11.408	22.000	7.323	15.948	3	2.900	2.983	3.050	0.076	3.112
PAH	Pyrene	9	7.950	30.811	110.000	32.730	51.099	3	5.500	9.083	16.250	6.207	19.547
Metals	Cadmium	9	0.070	2.277	7.800	2.565	3.867	3	0.058	0.059	0.060	0.001	0.062
Metals	Chromium	9	14.100	74.267	167.500	54.164	107.840	3	15.150	20.017	29.200	7.958	33.432
Metals	Copper	9	6.400	9.717	12.100	1.905	10.897	3	6.400	7.917	10.600	2.330	11.845
Metals	Gold	9	1.100	1.700	2.500	0.475	1.994	3	1.400	1.667	2.000	0.306	2.182
Metals	Lead	9	3.050	6.089	8.300	1.699	7.142	3	1.900	2.617	3.500	0.813	3.987
Metals	Mercury	9	0.050	0.201	1.265	0.400	0.449	3	0.050	0.053	0.055	0.003	0.057
Metals	Nickel	9	10.200	19.750	29.500	6.048	23.499	3	16.200	21.033	29.000	6.952	32.753
Metals	Silver	9	0.065	0.377	0.700	0.209	0.507	3	0.058	0.059	0.060	0.001	0.062
Metals	Tin	9	0.800	1.434	2.200	0.495	1.741	3	1.300	1.493	1.600	0.168	1.776
Metals	Zinc	9	27.300	37.511	47.000	6.721	41.677	3	22.800	28.367	38.700	8.958	43.468

Table 3-11. Statistical Summary of Chemical Concentrations in Clam Tissues (May 1996) from Area 8, NUWC Keyport, and Reference Area

Chemical Class	Chemical	Site Stations						Reference Stations					
		N	Minimum	Mean	Maximum	SD	UCL95	N	Minimum	Mean	Maximum	SD	UCL95
Base-neutral Extractables	Benzoic Acid	9	500.000	1730.093	2700.000	642.588	2128.401	3	495.000	1065.000	1400.000	496.160	1901.454
Base-Neutral Extractables	Phenol	9	100.000	236.852	736.667	271.757	405.300	3	100.000	100.000	100.000	0.000	100.000
PAH	Fluoranthene	9	4.975	10.997	20.000	5.610	14.475	3	4.950	5.967	8.000	1.761	8.935
PAH	Phenanthrene	9	27.225	34.596	68.613	15.021	43.906	3	27.225	28.025	29.625	1.386	30.361
PAH	Pyrene	9	27.225	109.943	484.375	167.184	213.572	3	27.225	27.275	27.375	0.087	27.421
Metals	Cadmium	9	0.215	1.977	5.700	2.134	3.300	3	0.205	0.265	0.370	0.091	0.419
Metals	Chromium	9	0.390	2.743	7.275	1.851	3.891	3	0.200	1.337	2.860	1.372	3.649
Metals	Copper	9	1.110	1.477	1.710	0.176	1.586	3	0.900	1.158	1.465	0.286	1.640
Metals	Hexavalent Chrome	9	0.490	2.175	6.500	2.080	3.464	3	0.500	1.090	2.270	1.022	2.813
Metals	Lead	9	0.050	0.093	0.210	0.060	0.131	3	0.050	0.125	0.165	0.065	0.235
Metals	Mercury	9	0.012	0.036	0.181	0.055	0.070	3	0.006	0.011	0.017	0.006	0.021
Metals	Nickel	9	0.400	0.850	1.750	0.487	1.152	3	0.500	1.150	2.050	0.805	2.507
Metals	Silver	9	0.109	0.542	1.455	0.410	0.796	3	0.035	0.091	0.150	0.058	0.188
Metals	Zinc	9	11.100	14.100	17.250	1.918	15.289	3	15.400	15.650	16.100	0.391	16.308

Table 5-1. Sampling Locations, Frequencies, and Analytical Requirements for Area 1 Monitoring Stations.

Sample Location	Sample Frequency			Analytes				
	Spring 2000 *	Once/ year	Once/ 2 years	Once/ 5 years	VOCs	SVOCs	PCB/ Pesticides	Metals**
Upper Aquifer Wells					X			
1MW-1		X			X			
MW1-2		X			X			
MW1-4		X			X			
MW1-5		X			X			
MW1-16		X			X			
MW1-17		X			X			
MW1-41		X			X			
MW1-8	X				X			
MW1-10	X				X			
Intermediate Aquifer Wells								
MW1-25			X		X			
MW1-28			X		X			
MW1-39			X		X			
MW1-7	X				X			
MW1-9	X				X			
Deep Wells								
PUD		X			X			
Navy #5		X			X			
Seep								
SP1-1			X				X	
Surface Water								
DB-14			X		X			
TF-19			X		X			
MA-09			X		X			
MA-11			X		X			
MA-12		X			X			
Sediment								
MA-09			X#	X		X	X	X
MA-11				X		X	X	X
MA-14			X#	X		X	X	X
TF-18				X		X	X	X
TF-20				X		X	X	X
TF-21				X		X	X	X
DB-05				X		X	X	X
DB-07				X		X	X	X
DB-08				X		X	X	X
Tissue (Clams)								
TF-18				X	X&	X	X	X
TF-20				X	X&	X	X	X
TF-21				X	X&	X	X	X
DB-05				X	X&	X	X	X
DB-07				X	X&	X	X	X
DB-08				X	X&	X	X	X

Notes:

* Spring 2000 represents additional sampling agreed upon by the Navy and Ecology.

** Metals analyses include arsenic, beryllium, chromium, lead, mercury, nickel, and zinc.

\# MA-09 and MA-12 will be sampled in spring 2000 and spring 2002. Depending on the sampling results, the sample frequency of these two stations will be changed to once every 5 years after 2002.

& Tissue samples will be analyzed for VOCs only in the first roun

After the first 5 years, sampling frequency for all sample media and locations will be reduced to once every 5 years; however, the actual sample location and frequency will be re-evaluated after the first 5 years of sampling.

Table 5-2. Sampling Locations, Frequencies, and Analytical Requirements for Area 8 Monitoring Stations.

	Sample Frequency			Analytes						
Sample Location	Spring 2000 *	Once/ year	Once/ 5 years	VOCs	Cyanide	Dissolved Metals	Total Metals	Chromium Speciation	TPH-Heavy Oil	SVOCs
Groundwater Monitoring Wells										
MW8-8		X		X	X	X		X		
MW8-9		X		X	X	X		X		
MW8-11		X		X	X	X		X		
MW8-12		X		X	X	X		X		
MW8-14		X		X	X	X		X		
MW8-16		X		X	X	X		X		
MW8-10	X			X						
MW8-15	X			X						
Seep										
Seep A		X		X	X	X		X		
Seep B		X		X	X	X		X		
Sediment and Tissue										
1			X		X		X			X
2			X		X		X			X
3			X		X		X			X
4			X		X		X			X
5			X		X		X			X
6			X		X		X			X
7			X		X		X			X
8			X		X		X			X
9			X		X		X			X
IRAP TPH Monitoring **										
MW8-2			X						X	
MW8-9			X						X	
SEEP A			X						X	
Physical Check			X						X	

Notes:

* Spring 2000 represents additional sampling agreed upon by the Navy and Ecology.

** IRAP TPH monitoring will be conducted once in 2000, and again in 2004 before the next 5-year review. At that time, Navy and Ecology will determine if further monitoring is required.